Kinesiology Handbook

Study Guide and Laboratory Manual

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EDITOR'S INTRODUCTION

KINESIOLOGY has for many years been recognized by teachers as a subject t was difficult to teach successfully Among the many reasons for this are that are especially important (1) the muscles, covered by the skin, can actually be seen in action, and when they must be seen only in imagination, as the case when instruction is limited to the classroom, it becomes doubly d to visualize them later, and (2) the concepts of mechanics have usually n taught with no relationship to the movements of man, and as a result, e seemed remote from any practical use to the physical educator

The laboratory approach does much to dispel the mysteries of kinesiol-, for the student himself sees and feels and experiments. Dr Scott has wn her ingenuity in departing from stereotyped patterns in assembling the eriments and problems contained in this manual Students who are con ted through these experiments will *remember* their kinesiology, and this a consummation devoutly to be wished but not too frequently achieved.

C H. McCLOY

ACKNOWLEDGMENTS

Acknowledgments are gratefully extended to Dr C H McCloy for his editorial reading and suggestions, to Virginia Dix Sterling for assistance on the anatomical illustrations, and to my many students in kinesiology over a period of several years who have made many positive suggestions, helped with the development of some of the techniques, and by their questions and difficulties have stimulated me to develop new teaching devices for clarification of subject matter

M. G S

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INTRODUCTION

This collection of materials is designed as a workbook and study aid for students of kinesiology The content of kinesiology courses is so detailed and so broad that it seems desirable for the student to have a means of assembling data to supplement and illustrate the subject matter discussed in the text. The possession of this supplementary material is perhaps less valuable than the process by which it is obtained. Conduct of the projects presented here will call for various procedures.

The procedures demanded in this workbook are suggestive of study methods. It is only the most exceptional student who can read the text and at the same time see significant implications and the connection with his ultimate goal of success in massage, remedial gymnastics, teaching of sports, or other work. It is hoped that the projects presented here will help him to make that application.

For example, the drawings which the student may complete should serve to visualize joint and muscle action. The problems will illustrate basic principles and provide illustrations from different activities, both simple and complex. The aim is for the student to be able to evaluate an activity or exercise in terms of the parts of the body affected, the results produced, and the significance in both respects of ...nst ons in performance. Most of the problems can be completed in a single class or by a daily assignment. A few call for prolonged work. Some of both types should be tried if time permits

A mastery of anatomical description of articulations and muscles is desirable before undertaking kinesiological work. The portion of this workbook dealing with ...atomy may be used during an anatomy course or may be used as a review by the ...dent of kinesiology

Most kinesiology courses are too limited in time to afford opportunity for completion of all projects presented here. Some institutions lack the laboratory space and equipment to allow each member of a large class to carry on each project As means of overcoming this difficulty, the following procedures may be followed

(a) Projects which may be conducted individually or in small unsupervised ...oups may be completed as assignments outside of class and the results compared discussed briefly in class

(b) Demonstrations may be conducted by the instructor or a class member for ... entire class.

(c) Committees may be organized within the class, each working simultaneously on a different project which will be demonstrated or reported later to the entire class.

As an aid to students and instructors, the Table of Contents suggests the use to be made of each lesson. The three alternatives indicated are

assignment for out-of-class study or preparation
demonstration for the class
laboratory experience for every member of the class.

Each lesson is marked with an X indicating that probably best results will be obtained through the procedure so checked. Each lesson is further marked with an x indicating second best procedure.

Furthermore those lessons which can be omitted without handicapping the student too much have been starred (*) This does not mean that the content is unimportant. It simply means that it has been found that the majority of students can acquire the information readily through reading or class discussion.

This outline, then, provides for 15 to 20 daily assignments, 9 demonstrations, 5 to 11 laboratory projects, 4 to 10 long term studies, all with alternate procedures suggested to fit the time and facilities available for each class

This workbook is designed primarily to accompany the text of *Analysis of Human Motion* For that reason it parallels the book very closely in topics and outline However, it should prove useful in courses other than those organized around this text

Lesson 1

Kinesiology What and Why?

References * Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap I
Glassow Ruth, *Fundamentals in Physical Education*, Lea & Febiger, Philadelphia, 1932, pp 17 20
Steindler, Arthur What Has Biokinetics to Offer to the Physical Educator *Journal of Health and Physical Education* v 13, November 1942, p 507

When did you start learning to throw a ball, to swing a tennis racket or a baseball bat, to swim, or to ride a bicycle? Can you remember what it feels like to be a beginner? Unless you have started some entirely new skill recently, you probably cannot.

Have you had a younger sister who very much wanted you to teach her how to play tennis or badminton? Of course, she probably did not ask you outright, she just pretended she could play and did not mind that "swing and miss" But she really wanted you to teach her how to play the game well enough so that you could enjoy playing it together But do you know *why* her balls or birds always behaved differently from yours?

Can you look forward with confidence to the day when your students start asking you "Why—, why— why—?" Maybe you can answer some of the "why's" but there are always endless others and the more you learn to answer, the easier the others are.

Unfortunately, as we grow up we cease to ask "Why?" as many times as when we were children. Start asking yourself now *why* you are being taught the details of some skill or *why* you perform other skills as you do.

Try answering the following questions in a way to show *how* improved results are obtained. It is not adequate to say this is the way to add distance or accuracy, or this is the way to avoid failure or injury

1 Why bend your knees in preparation for a jump? ____________________

____

____

____

____

* The references in this manual are designed to direct the student to discussions in *Analysis of Human Motion* and to supplement those references given at the close of each chapter cited in the text.

2. Why keep your elbow straight when striking a tennis ball?

3. Why bend your elbows when catching a ball?

4. Why step forward with the opposite foot from the throwing arm when making a throw?

5. Why step forward while throwing a ball?

6. Why use a wrist snap when throwing a baseball or striking a golf ball?

7. Why stand sideward to the pitcher when in the batter's box?

8. Why hold a tennis or badminton racket near the end of the handle rather than several inches up the handle?

9 Why use a running approach on the javelin throw?

10 Why lean in when turning the corner on a bicycle?

11 Why lean forward if preparing to make a quick running start?

12. Why stand with feet apart when spotting for a tumbler?

13 Why arch your back when doing a head stand or hand stand?

14 Why roll up tight when doing a forward roll?

15 Why start the ball low when making a bounce in basketball?

16 Why are short steps less dangerous than long ones on ice?

17 Why bend your knees when landing after a jump?

18 Why can a subject with muscles too weak for ordinary use perform movements with those muscles when submerged in water?

19 Why does a swimmer who is standing in 3 or 4 feet of water find it impossible to bend over and pick up a rock he has dropped at his feet?

20 Why do not all balls bounce in the same way?

21. Why do some golf balls seem to soar and others roll along the ground?

22 WHY does the degree of tension of the tennis racket strings make a difference in your game?

23 WHY do the shoulders sag and the head hang forward so easily in standing and sitting positions?

24 WHY is it difficult or sometimes impossible for a person to bend the hip joint and at the same time keep the knees straight?

25 WHY is the "toes out" position poor for walking?

If you can answer all 25 questions fully you are going to find the rest of the assignments very easy If you can not answer some of them, be alert, you will find these answers, and many others, in the lessons to come, for kinesiology is largely an explanation of *why* we move as we do

Add to the above questions, others for which you would like to know an answer Start the list of questions now, and keep adding to it as new questions arise in your activity classes or in your reading When you find a partial or complete answer in the text make note of it opposite the question.

Questions	Answers	Reference

PART I

STRUCTURE AND FUNCTION

The material in this section is designed primarily as an anatomical and physiological review in preparation for kinesiological application. However, if anatomy and kinesiology are not taught in the same course, this section may be used in the initial learning stages as study aids.

Lesson 2

Motion in Relation to Joint Structure

References Scott, M Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap II

DeGaris, C F., Movable Joints and Joint Movements,' *Journal of International College of Surgeons* v 5 September 1942, pp 380-389

Elftman, Herbert, Skeletal and Muscular Systems; Structure and Function, *Medical Physics* Year Book Publication, Chicago, 1944 pp. 1420-1424

Jones, F Wood, *Structure and Function of the Foot,* Williams and Wilkens Co., Baltimore, 1944 Chap XII, XXI

Leighton, Jack R., A Simple Objective and Reliable Measure of Flexibility, *Research Quarterly* v 13, May 1942, p 205

Truslow Walter *Body Poise* Williams and Wilkens Co., Baltimore, 1943 Chap I

West, Catherine Measurement of Joint Motion, *Archives of Physical Medicine* v 26 July 1945 pp 414-425

Equipment A goniometer (A goniometer is a device for measuring angles. It may be purchased from companies supplying laboratory equipment, or, for this study, an improvised form or large size protractor may be used.)

Project A Study of scapular movements.

Stand behind a subject who has removed clothing from the waist up Use a skin pencil and lightly outline inferior angle and vertebral border of scapula Have subject slowly raise arms sideward.

________1. In how many degrees of abduction is the arm when the inferior angle starts moving?

________2. How many degrees is the scapula rotated upward at its greatest deviation from starting position?

________3 What is the position of the arm when the scapula first reaches its greatest rotation?

________4 Compare the above measures taken on all subjects in class Is there any uniformity regarding these facts?

________5 How much individual variation is noted?

Project B Study of shoulder joint range.

Stand behind a subject who has removed clothing from the waist up Use a skin pencil and lightly outline position of inferior angle and vertebral border of scapula.

________ 1. Have subject slowly raise arm sideward and record the degrees of abduction when scapula first starts rotating upward. (If you have performed both projects A and B compare figures as a check on reliability (or consistency) of measures They should be the same.)

________ 2. Have subject raise arm forward and record degrees of forward elevation (flexion) when scapula first starts rotating upward.

________ 3 Have subject raise arm backward and record the degrees of extension and abduction when the scapula first starts rotating upward.

4. Describe (or draw) the path of circumduction possible by shoulder joint action only Use the path of the hand as the path of circumduction. (For an example of drawings on circumduction see *Analysis of Human Motion*, pp. 14 and 25)

5 Describe or draw the path of circumduction possible by the combination of shoulder and shoulder girdle action.

Project C: COMPARISON OF RANGE OF MOTION IN DIFFERENT ARTICULATIONS.

Measure the degrees of motion (both angular and rotation around the longitudinal axis) in various articulations using a goniometer Be very careful to get action of a single joint only

Indicate position of the joint when rotation is measured (for example, knee)

ARTICULATION	MOTION	DEGREES	COMMENT

Articulation	Motion	Degrees	Comment

Compare class figures with those in *Analysis of Human Motion*, pp 31 33
What is class average for each? Class range?

Articulation	Comparison	Average	Range

1. What are the similarities in structure in the shoulder joint and the hip joint?

2. What are the similarities in function of the shoulder joint and the hip joint?

3. Why does the shoulder joint have a wider range of motion than the hip joint, even though the articular area on the head of the humerus is smaller than that on the head of the femur?

4. What are the similarities in structure of the elbow and the interphalangeal articulations?

5. What limits hyperextension in the elbow? In the fingers?

6. Draw a diagram of the lower extremity and indicate the direction of flexion in each articulation (hip, knee, ankle, toes)

7. Structurally the elbow and forearm have certain differences from the knee and lower leg. List those points of structural difference. How do they affect the action?

DIFFERENCES	EFFECT

8 What generalization can you make about the structure and function of the upper and lower extremities?

Lesson 3

Muscles of the Upper Extremity

References Scott, M Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap III

Daniels, Lucille, Marian Williams, and Catherine Worthingham, *Muscle Testing* W B Saunders Co., Philadelphia, 1946 pp 106-167

Elftman, Herbert, Skeletal and Muscular Systems Structure and Function *Medical Physics* Year Book Publication, Chicago 1944 pp 1420-1424

Spalteholz, Werner *Hand Atlas of Human Anatomy* J B Lippincott Co., Philadelphia, Vol. II 1933

Truslow Walter *Body Poise* Williams and Wilkens Co., Baltimore, 1943 pp 85-120

Equipment Several pencils with different colored leads.

Project A: MUSCLE POSITION AND SHAPE.

Draw the muscles on the framework presented in the pictures The drawing should be accurate in terms of both attachments and direction of muscle fibers.

Project B LINE OF PULL.

Draw in the line of pull of the muscle on the skeletal framework. Muscles functionally having two or more subdivisions should have a line of pull for each division of the muscle.

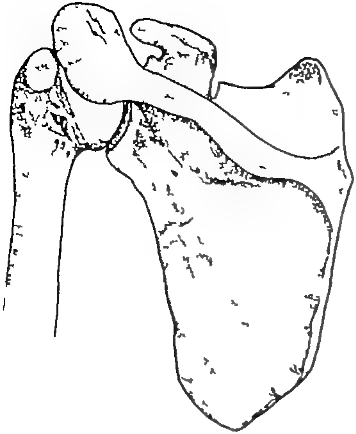

FIG. 1

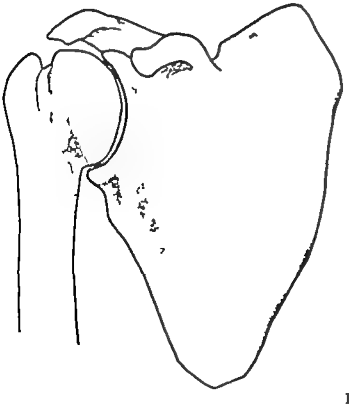

FIG. 2

Action	Synergists	Antagonists
Adduction of the wrist		
Flexion of the fingers		
Abduction of the fingers		

Lesson 4

Muscles of the Back

References: Scott, M. Gladys, *Analysis of Human Motion*, F S Crofts & Co., New York, 1942, Chap III

Daniels, Lucille, Marian Williams, and Catherine Worthingham, *Muscle Testing* W B Saunders Co., Philadelphia, 1946 pp 18-24 30-32

Elftman, Herbert Skeletal and Muscular Systems Structure and Function, *Medical Physics* Year Book Publication, Chicago, 1944 pp 1420-1424

Spalteholz, Werner *Hand Atlas of Human Anatomy*, J B Lippincott Co., Philadelphia, Vol. II, 1933

Truslow Walter *Body Poise*, Williams and Wilkens Co., Baltimore, 1943, pp 45-85

Equipment Several pencils with different colored leads.

Project A Muscle position and shape.

Draw the muscles on the framework presented in the pictures The drawing should be accurate in terms of both attachments and direction of muscle fibers.

Project B Line of pull.

Draw in the line of pull of the muscle on the skeletal framework. Muscles functionally having two or more subdivisions should have a line of pull for each division of the muscle

Project C Muscle groups.

List the muscles belonging to the following groups.

Action	Synergists	Antagonists
Extension of the spine		
Lateral flexion of the trunk		
Rotation of spine (only those muscles on the posterior aspect of the trunk)		

Muscles of the Abdomen

References: Scott, M. Gladys, *Analysis of Human Motion* F S. Crofts & Co., New York, 1942, Chap III

Daniels, Lucille, Marian Williams and Catherine Worthingham, *Muscle Testing,* W B Saunders Co., Philadelphia, 1946, pp 26-28, 34-36

Elftman Herbert, "Skeletal and Muscular Systems: Structure and Function," *Medical Physics* Year Book Publication, Chicago, 1944, pp 1420-1424

Spalteholz, Werner *Hand Atlas of Human Anatomy,* J B Lippincott Co., Philadelphia, Vol. II, 1933

Equipment Several pencils with different colored leads.

Project A Muscle position and shape.

Draw the muscles on the framework presented in the pictures The drawing should be accurate in terms of both attachments and direction of muscle fibers.

Project B Line of pull.

Draw in the line of pull of the muscles on the skeletal framework. Muscles functionally having two or more subdivisions should have a line of pull for each division of the muscle.

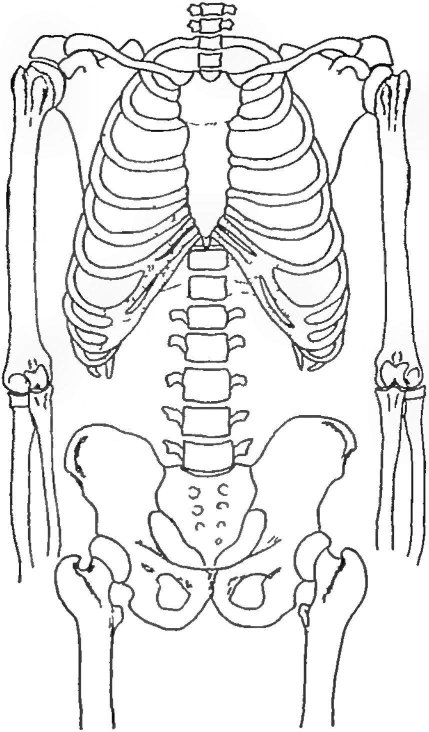

Fig. 7

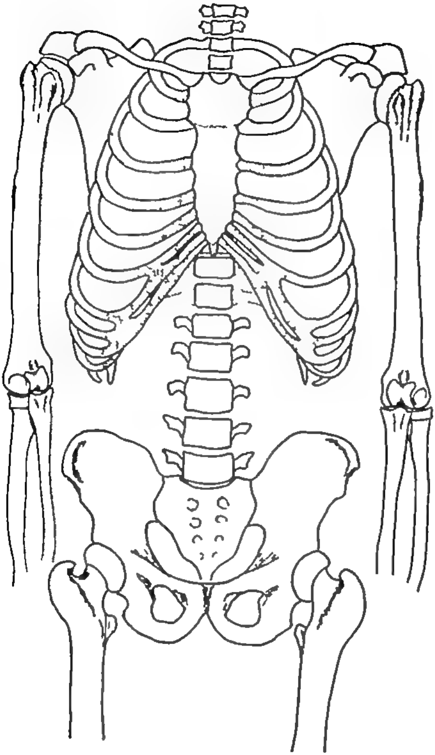

FIG. 7A

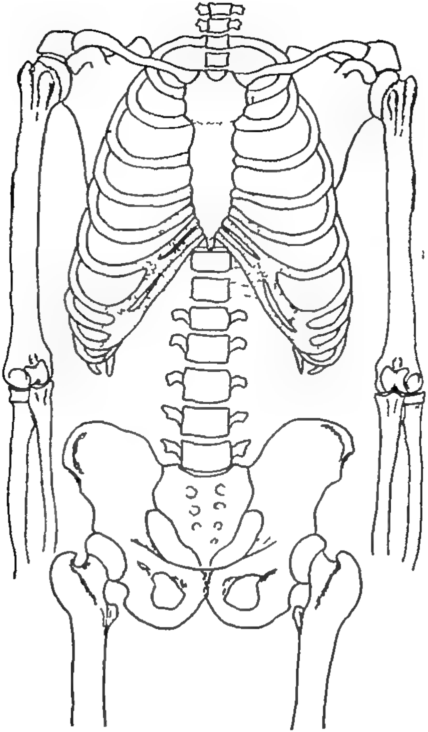

Fig 7b

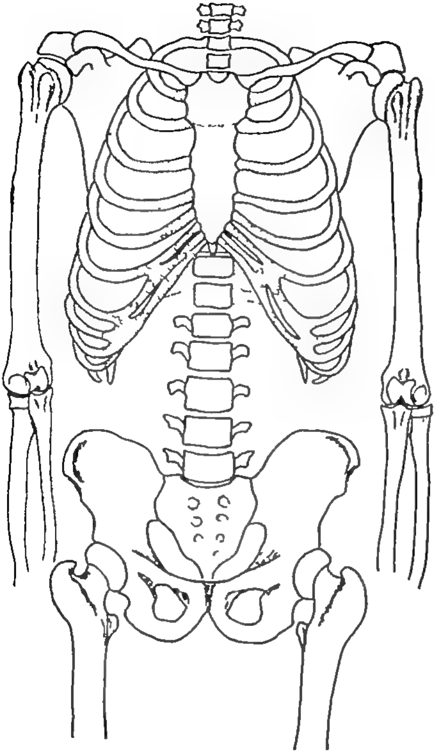

FIG. 7e

Project C MUSCLE GROUPS.

List the muscles belonging to the following groups.

ACTION	SYNERGISTS	ANTAGONISTS
Flexion of the spine		
Lateral flexion of the trunk (anterior aspect of trunk only)		
Rotation of spine (anterior aspect of trunk only)		

Lesson 6

Muscles of the Lower Extremity

References: Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap III

Daniels, Lucille Marian Williams and Catherine Worthingham, *Muscle Testing* W B Saunders Co., Philadelphia, 1946, pp 40-105

Elftman Herbert, Skeletal and Muscular Systems Structure and Function *Medical Physics* Year Book Publication, Chicago, 1944 pp 1420-1424

Spalteholz, Werner *Hand Atlas of Human Anatomy* J B Lippincott Co., Philadelphia Vol II 1933

Truslow Walter *Body Poise* Williams and Wilkens Co., Baltimore, 1943 pp 13-45

Equipment Several pencils with different colored leads.

Project A MUSCLE POSITION AND SHAPE.

Draw the muscles on the framework presented in the pictures The drawing should be accurate in terms of both attachments and direction of muscle fibers.

Project B LINE OF PULL.

Draw in the line of pull of the muscle on the skeletal framework. Muscles functionally having two or more subdivisions should have a line of pull for each division of the muscle

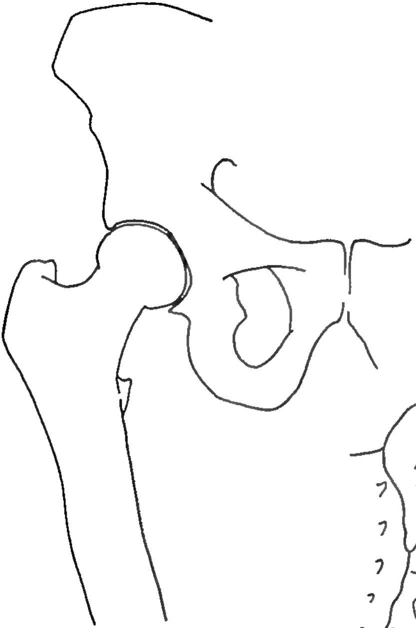

FIG. 8

FIG. 9

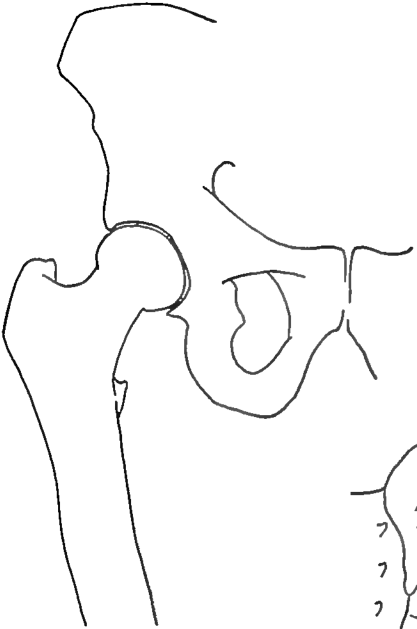

Fig. 8a

Fig 10

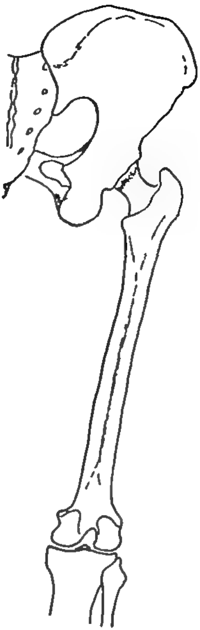

Fig. 11

Fig 10a

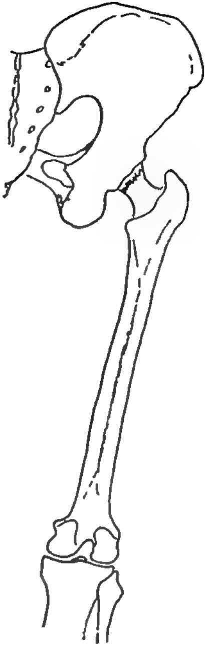

Fig. 11a

Fig. 10b

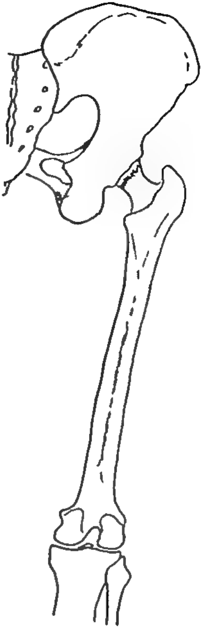

Fig. 11b

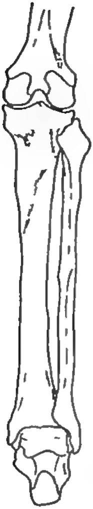

FIG. 13

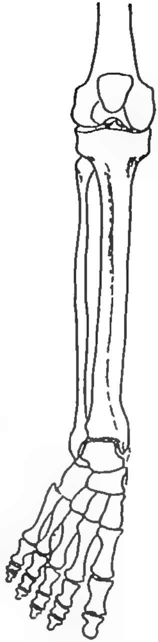

FIG. 12

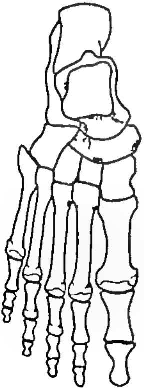

FIG. 14

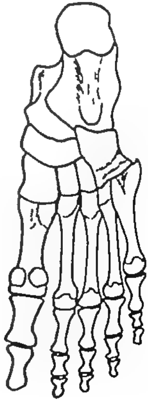

FIG. 15

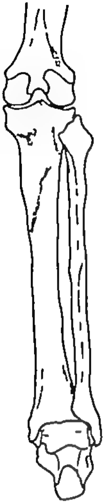

Fig 13a

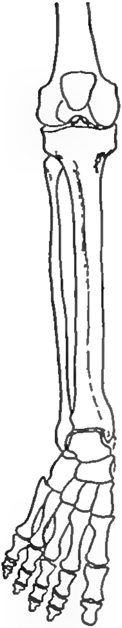

Fig. 12a

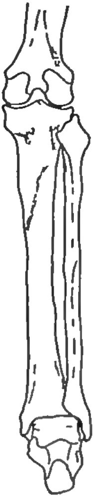

Fig 13b

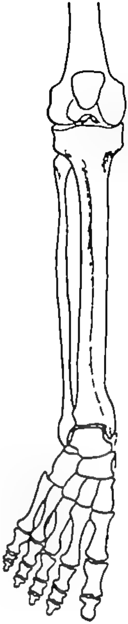

Fig. 12b

Project C MUSCLE GROUPS.

List the muscles belonging to the following groups.

ACTION	SYNERGISTS	ANTAGONISTS
Flexion of the hip		
Abduction of the hip		
Inward rotation of the hip		
Flexion of the knee		
Inward rotation of the knee		
Flexion of the ankle		
Inversion of the foot		
Flexion of the toes		

Muscles in the Process of Contraction

A muscle which is contracting in any instance where motion is permitted in the direction of the contraction, appears to shorten and thicken. This is isotonic (concentric) contraction.

A muscle which is contracting, in any instance where motion is not permitted, goes through the same physiological process as the one which shortens, and tension increases within the muscle and on its two attachments. This is isometric (static) contraction.

A muscle which is controlling or checking the rate and range of a movement may actually become longer even though it is in a state of contraction. This is eccentric contraction.

A muscle must pull on a bone it can not push.

References Scott, M Gladys, *Analysis of Human Motion*, F S. Crofts & Co., New York, 1942, Chap III

Smout, C F V and R. J S McDowall, *Anatomy and Physiology for Students of Psysiotherapy Occupational Therapy and Gymnastics* Edward Arnold & Co., London, 1945 pp 300-305

Höber Rudolf et al, *Physical Chemistry of Cells and Tissues* Blakiston Co., Philadelphia, 1945 Chap 33

Zoethout, William D., and W W Tuttle *Textbook in Physiology* C V Mosby Co., St. Louis, 1940, Chap VI

Project To PALPATE THE MUSCLES IN ACTION AS A STUDY TECHNIQUE AND TO VERIFY ACTIONS ACCORDED THEM

One method of studying muscle action is to watch the muscles changing shape during movement. Another is to place the hand over the muscle and feel the change of tension when the muscle goes into action. (Many of the deeper muscles can not be studied by this procedure.) In some cases observation of the tendon of insertion may be helpful in detecting muscular action.

Select a subject with clothing which permits exposure of muscles involved in the following actions Feel the muscles before starting, and during action. Differentiate, when possible between instances where the entire muscle acts and instances where only parts of the muscle act.

	Principal Muscle	*Synergistic Muscles Which can be Felt*
1. Raise arm sideward	______	______
2. Raise arm sideward against resistance	______	______
3 Flex the elbow	______	______
4 Extend the elbow against resistance	______	______
5 Flex the head (neck)	______	______
6. Turn face to right as head drops forward	______	______
7 Rise to tiptoes while standing	______	______
8. Extend the knee against resistance	______	______
9 In standing position, abduct leg	______	______
10 Sitting with knees straight and legs parallel, turn soles of feet toward each other while trying to dorsal flex the foot	______	______

Under what circumstances do muscles shorten and thicken when contracting?

Explain the terminology used to identify the three types of contraction

What is the effect of resistance on the response of the muscle?

Tonus of the Muscle

Muscle tonus is helpful in preventing jerky movements when starting from a resting position and also in reducing the interval between stimulation and the start of movement.

References Scott, M Gladys, *Analysis of Human Motion* F S. Crofts & Co., New York, 1942, Chap IV

Eggleton, M. Grace, *Muscular Exercise* Paul, Trench, Trubner & Co., London, 1936 pp 179 189

Zoethout William D., and W W Tuttle *Textbook in Physiology* C V Mosby Co., St. Louis, 1940 Chap VI

Equipment A hinged joint model (made of two small boards hinged together) with a rubber band attached across the joint. (See Figure)

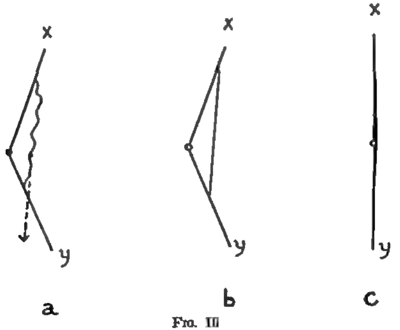

FIG. III

Project To DEMONSTRATE THE EFFECT OF VARYING DEGREES OF TENSION ON THE RUBBER BAND AS ILLUSTRATIVE OF VARYING DEGREES OF TENSION IN MUSCLES.

Place the model on a table as in *a* of the illustration with the elastic loose Then pull steadily according to the line of force indicated.

1. What happens before end X starts moving?

2. Describe the reaction of X when it does move

Then place the model on the table in position *b* and hold the ends. Release end X.

3. What is the effect?

Replace and then release end Y

4. What is the effect?

Repeat in position *c*

5. How does the reaction compare?

6. Why is relaxation never quite similar to that represented in *a*?

7. How much does tonus vary?

8. What are the factors determining variations in tonus?

9. If you are expected to make a quick muscular response should you try to relax as much as possible in preparation for it?

10. If the force which causes a muscle to be stretched is released why is the response seldom like that of the stick in position *c*?

Lesson 8

Tonus of the Muscle

Muscle tonus is helpful in preventing jerky movements when starting from a resting position and also in reducing the interval between stimulation and the start of movement.

References Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap IV

Eggleton, M. Grace, *Muscular Exercise*, Paul, Trench Trubner & Co., London, 1936, pp 179-189

Zoethout, William D., and W W Tuttle, *Textbook in Physiology* C V Mosby Co., St. Louis, 1940 Chap VI

Equipment A hinged joint model (made of two small boards hinged together) with a rubber band attached across the joint. (See Figure.)

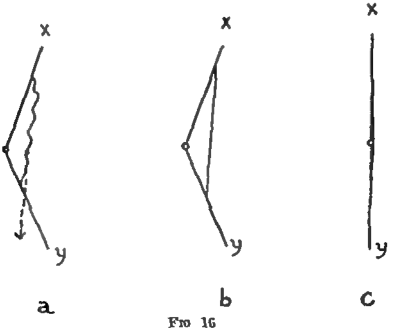

Fig 16

Project To DEMONSTRATE THE EFFECT OF VARYING DEGREES OF TENSION ON THE RUBBER BAND AS ILLUSTRATIVE OF VARYING DEGREES OF TENSION IN MUSCLES.

Place the model on a table as in *a* of the illustration with the elastic loose Then pull steadily according to the line of force indicated.

1. What happens before end X starts moving?

2. Describe the reaction of X when it does move.

Then place the model on the table in position *b* and hold the ends Release end X.

3. What is the effect?

Replace and then release end Y

4. What is the effect?

Repeat in position *c*.

5. How does the reaction compare?

6. Why is relaxation never quite similar to that represented in *a*?

7. How much does tonus vary?

8. What are the factors determining variations in tonus?

9. If you are expected to make a quick muscular response should you try to relax as much as possible in preparation for it?

10. If the force which causes a muscle to be stretched is released, why is the response seldom like that of the stick in position *c*?

Lesson 9

Muscle Fatigue and Contracture

After a muscle has warmed up, it continues for a time to give optimum performance, i.e., full contraction and relatively full relaxation Then it gradually demonstrates the effects of progressive fatigue by less extensive contractions and less relaxation Continued use eventually brings it to the point where it can neither contract when stimulated or relax when the stimulus is removed.

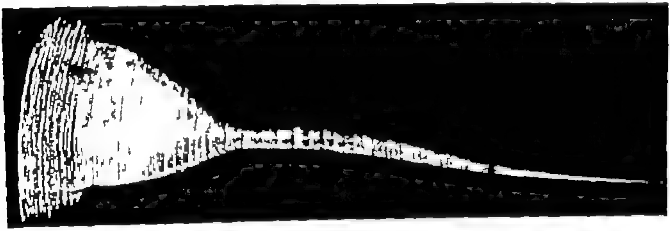

FIG. 17

In the kymographic recording above, the left hand side of each peak represents the contraction resulting from a single stimulus. The right hand side represents the relaxation following that contraction. The height of the peak represents the relative extent of the contraction. The depth of the trough between contractions represents the relative relaxation between contractions

References Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap IV
Francis, Carl C., Clinton Knowlton and W W Tuttle, *Textbook of Anatomy and Physiology* C V Mosby Co., St. Louis, 1943 pp 194-197
Schneider Edward C., *Physiology of Muscular Activity* W B Saunders Co., Philadelphia, 1939 Chap. XVI
Zoethout William D., and W W Tuttle *Textbook in Physiology* C V Mosby Co., St Louis, 1940 Chap VI

Equipment A small pulley, cord, weight of several ounces adhesive tape.

Project A STUDY OF THE KYMOGRAPHIC RECORDING ABOVE.

1. Determine, in the figure above, the proportion of time represented in which the muscle is operating at its optimum.

2. Determine the proportion of time in which it is operating without marked fatigue

3. Determine the point beyond which you could not comfortably proceed (judged by feeling in the muscle, not general respiratory discomfort)

Project B TO PRODUCE COMPLETE FATIGUE OF A MUSCLE.

Seat the subject beside a low table or in an arm chair. The hand and arm should be placed on the table in such a way that the arm is relaxed but supported all along the forearm and to the base of the fingers. The hand should be strapped to the support so the weight will not lift the hand.

The pulley should be suspended approximately above the end of the middle finger. Prepare the equipment with the cord through the pulley and weight attached. The weight should be about three-fourths of the maximum which the extensor can lift.

The hand is strapped down, palm up. The cord is attached at the articulation of the second and third phalanges of the middle finger and made secure by adhesive tape. (Avoid tight strips of adhesive *around* the finger in such a way as to shut off circulation.) When the extensor is not working the weight will cause flexion of the finger. Start rhythmical extension of the finger to the point where the finger is straight and horizontal. Then let finger relax. The rate should not allow any marked pause at either extension or flexion. Continue until the finger will no longer move.

Record the number of extensions before it appeared difficult to make contraction. ____________

Record the number of extensions at which it appeared to no longer relax fully between contractions ____________

Record the total number of extensions before it ceased to be able to function __________

What muscle is responsible for this operation? __________

Assuming that it is desirable to have the experiment completed within a comparatively brief time—

why is it better to use the third finger rather than the second or fifth fingers? __________

why is it better to use extensor action rather than flexor action? __________

What would be the effect of a heavier weight? __________

What would be the effect of a lighter weight? __________

What would be the effect of a slow controlled flexion on each cycle? __________

What are the flexors of the third finger doing during the experiment? __________

The base line below represents the total time during which the finger worked. Construct a curve over the base line showing the relative proportion of time in which the muscle functioned easily and effectively, and the point at which it ceased to relax readily

Was the final contraction similar to the final one in the illustration at the beginning of the lesson? (If it was similar, the muscle is in a "cramp" and is in need of heat and massage.)

Does an individual ordinarily work to the point of muscle contracture?

Why?

PART II

APPLIED MECHANICS

The lessons in Part II are designed to parallel the study and class discussion throughout the course in kinesiology They are aimed at giving the student experience in connection with principles discussed and thereby help him in retaining that information.

See Part III for additional projects which require longer than the daily lesson to complete, but which may be used as additional projects if started early enough in the course.

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Lesson 10

Movements of Body Segments are Angular Movements

References: Scott, M. Gladys, *Analysis of Human Motion* F. S. Crofts & Co., New York, 1942, Chap V
DeGaris, C F., "Movable Joints and Joint Movements," *Journal of International College of Surgeons* 5 September, 1942, pp. 380-389
Daniels, Lucille, Marian Williams, and Catherine Worthingham, *Muscle Testing* W B Saunders, Philadelphia, 1946 pp 40-186

Project To TRANSLATE ALL MOTION INTO ANGULAR MOVEMENT

Perform the following movements and complete the outline given below All movements start from the anatomical position unless otherwise stated.

	Plane of Motion	Axis	Degrees of Rotation
1. Arms raised sideward, midway from side to shoulder level	______	______	______
2 Arms raised sideward to shoulder level	______	______	______
3 Arms raised forward until over head	______	______	______
4 Elbow flexed until forearm is horizontal	______	______	______
5 Arms start abducted at shoulder level, palms forward, elbow flexes until fingers touch chest	______	______	______
6 Hand placed on table palm up flex fingers at metacarpal phalangeal articulation until fingers are as nearly vertical as possible	______	______	______
7 Flex knee as fully as possible	______	______	______
8 Standing erect one leg raised as nearly forward as possible	______	______	

9 Standing erect, one leg raised sideward as far as possible without moving trunk	______	______	______
10 Standing on one foot, knee on free leg straight, turn toes in toward other foot as far as possible, then turn out as far as possible	______	______	______

Lesson 11

Internal Muscle Structure

Muscle fibers are arranged in variations of parallel and penniform types.
The length of the fibers determines the range of contraction
The physiological cross section of the muscle determines its contractile force

References Scott, M. Gladys, *Analysis of Human Motion*, F S Crofts & Co., New York, 1942, Chap VI

Haines, R. W., Muscles of Full and Short Action ' *Journal of Anatomy*, v 69 October 1943 pp 20-24

Höber Rudolf, *Physical Chemistry of Cells and Tissues*, Blakiston Co., Philadelphia, 1945 pp 453-454

Project A CONSTRUCT MODELS OF EACH OF THE PRINCIPAL TYPES OF INTERNAL MUSCLE CONSTRUCTION This can be facilitated by modeling after a specific muscle However, do not be so concerned with details of proportion and size that the characteristic arrangement of the fibers within the muscle is lost.

Equipment Use pipestem cleaners to represent muscle fibers and a piece of cork or several pieces glued together and cut to represent the form of the tendon or bone. Adhesive tape and glue may be used to make cleaners adhere in or on the cork.

Construct the following models

1. Longitudinal, parallel, short fibers (intercostals)
2. Longitudinal, fusiform (pronator teres)
3. Longitudinal, triangular (deltoid)
4. Penniform, simple (peroneus longus)
5. Penniform, bipennate (rectus femoris)
6. Penniform, multipennate (gastrocnemius)

Project B USING A GIVEN AMOUNT OF MUSCLE STRUCTURE, CONSTRUCT MODELS HAVING DIFFERENT POTENTIALS FOR EXTENT AND STRENGTH OF CONTRACTION

Equipment Use twine string to represent muscle fibers and adhesive tape for tendons or bones. Use 36 inches of string and adhesive one inch wide for each model. Construct 3 models

1. Intercostals—split adhesive in two long strips, cut string into inch lengths and fasten to adhesive.

2. Soleus—one piece of adhesive 3 inches long, split upper two inches into six strips, leave lower inch intact for tendon of Achilles. Use another two-inch strip for tibia fibula. Cut string into two-inch lengths. Attach both to bone and ligamentous branches
3. Sartorius—two small pieces of adhesive Cut string into 4 nine-inch lengths

Answer the following questions:

1. What are the advantages of the penniform arrangement?

2. What are the advantages of a long muscle like the sartorius?

3. What generalizations can you make about the internal structure of the muscle in relation to the articulation which it affects?

Lesson 12

Leverage

References: Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap VI
Luhr Overton, *Physics Tells Why* Jaques Cattell Press, Lancaster Pennsylvania 1946, Chap 8
Truslow Walter *Body Poise* Williams and Wilkens Co., Baltimore, 1943, Chap I

Equipment A 12 or 15 inch ruler or stick may be used, two or three small objects of known weight which may be taped or tied to the lever, small spring scale.

Project: To STUDY THE EFFECT OF DIFFERENCES IN LENGTH OF LEVER ARMS AND OF DIFFERENT RESISTANCE.

Second class. Attach spring scale by means of a string or by putting a hole through the ruler near its end. Attach the weight 3 inches from the axis.

Start with ruler lying on top of a table with one end held firm against a book or finger Lift slowly so lever is just off table

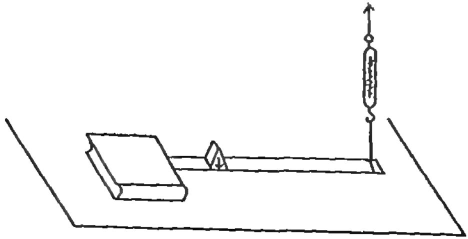


FIG. 18

Record below the length of each lever arm, weight of resistance, and pull registered on the scale

Repeat with weight moved out to 6 inches and again at 9 inches.

Resistance arm ____, force arm ____, resistance ____, force ____.

Resistance arm ____ force arm ____ resistance ____, force ____

Resistance arm ____ force arm ____ resistance ____, force ____.

What is the effect of lengthening the resistance arm?

Third class Same position of ruler Fasten weight on outer end of ruler Attach the scale at 3 inches and record all values.

Repeat with scale attached at 6 inches and 9 inches.

Resistance arm ____ force arm ____ resistance ____, force ____.

Resistance arm ____ force arm ____ resistance ____ force ____.

Resistance arm ____ force arm ____ resistance ____, force ____

What is the effect of changing the position of the pulling force?

How do the two types compare in effectiveness? What compensating value is obtained in the uneconomical one?

What generalizations can be derived from the two illustrations above which will apply also to the first class lever?

Does the forearm always operate as the same class of lever? Explain.

List other segments which are similar to the forearm with respect to different leverage

Explain the following statements

The first class lever is well designed for balance.

The second class lever is designed for power and economy

The third class lever is built for speed.

Lesson 13

The Effectiveness of Muscle Pull

The angle of pull of a muscle changes with every change in position of the part moved

The angle of pull is relatively small for most muscles through a considerable portion of their range.

References Scott M. Gladys, ***Analysis of Human Motion*** F S Crofts & Co., New York, 1942, Chap VI and VII
Luhr Overton, ***Physics Tells Why*** Jaques Cattell Press, Lancaster Pennsylvania, 1946 Chap 2

Equipment A small stick or ruler Make a hole or notch in one end and attach a string

Project To STUDY THE EFFECT OF THE ANGLE OF PULL OF THE MUSCLE.

1. Place the stick out flat on the table and straight in front of you with the finger of the left hand against the near end and the string attached to the far end. Stretch the string back directly on top of the stick and pull directly toward you

What is the angle of pull? ______________________

What is the perpendicular distance? ______________________

What is the effect on the lever? ______________________

What is the effect on the finger holding the lever to prevent slipping? ______________________

2. Repeat, but holding the fingers grasping the string about two inches above the near end of the lever

What is the angle of pull at the start? ______________________

What is the angle of pull when the lever has rotated 30°? ______________________

What is the perpendicular distance? ______________________

What is the effect on the lever? ______________________

What is the effect on the finger holding the lever to prevent slipping? ______________________

Cite an example of a muscle which pulls in this manner ______________________

3 Place a large spool, or any object with a rounded or narrow top surface, at the near end of the lever and hold in place. Place the string across the spool and pull directly toward you with fingers along the table.

What is the angle of pull? ______________________

What is the perpendicular distance? ______________________

What is the effect on the lever? ______________________

What is the effect on the finger holding the lever to prevent slipping? ______________________

Cite an example of a muscle which pulls in this manner ______________________

What is the principal effect of the spool? ______________________

What would be the effect on the lever if the spool were held at the edge of the table and the string were pulled directly downward after passing over it?

What is meant by the moment of rotation of a muscle pull? How is it related to this project?

What structures in the body give the same effect as the spool?

Indicate the way in which the angle by which the resistance applies to the lever affects the effectiveness of resistance

Lesson 14

Lever Length in Relation to Rate of Movement

The longer the lever, the slower the swinging time for a given amount of force.

References Scott, M Gladys, *Analysis of Human Motion* F S Crofts & Co., New York 1942, Chap VI

Equipment Two or three lightweight sticks (strips of lath will serve) one-foot, two-foot, three foot lengths *Bore a hole in similar positions in the upper end* of each Smooth out hole so as to reduce friction. A large nail or other round metal bar to be inserted into holes in sticks. It is preferable, but not essential, to have this axle fastened into something firm so it does not need to be held. Stop watches.

Project To STUDY THE EFFECT OF VARYING THE LENGTH OF THE LEVER, OR THE DISTANCE TO THE CENTER OF GRAVITY OF THE LEVER, ON THE SWINGING RATE.

Use two sticks of different lengths. Pull up to the horizontal position and release simultaneously With a stop watch on each, time the amount of time for 10 full oscillations. Compare times Or, if only one stop watch is available for the entire class count the number of trips across in 10 seconds.

______________ ______________

Use two sticks which are hinged in the middle to represent knee action. Leave one hanging straight and fasten the other up in a position of almost full flexion. Pull up to the horizontal position and release simultaneously Count the number of trips across for each in 10 seconds.

______________ ______________

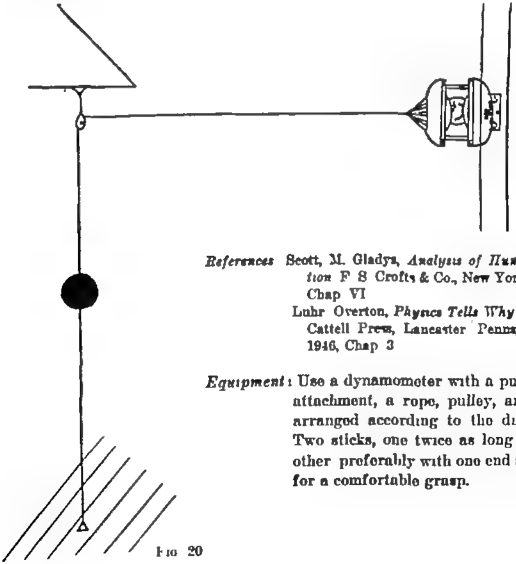
List examples where arm or leg is flexed to reduce swinging time or to reduce resistance to swinging

Lesson 15

Force Developed at the End of a Long Lever

When a lever moves, each point on the lever describes its respective arc in exactly the same time as every other point. If the lever is a long one, the points near the outer end of the lever are moving at a much faster rate than those near the fulcrum

The momentum resulting from this high rate of speed may be imparted to other objects which are in contact with the lever



References Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap VI

Luhr Overton, *Physics Tells Why* Jaques Cattell Press, Lancaster Pennsylvania, 1946, Chap 3

Equipment: Use a dynamometer with a push pull attachment, a rope, pulley, and ball arranged according to the diagram. Two sticks, one twice as long as the other preferably with one end shaped for a comfortable grasp.

Fig 20

Project To COMPARE THE STRIKING FORCE OF TWO SIMILAR LEVERS, ONE OF WHICH IS LONGER THAN THE OTHER.

Hold the stick so that it can be swung through a horizontal arc of either 90° or 180° to contact the ball attached to the equipment. Establish a comparatively slow rate of swinging which can be timed and kept uniform for each lever (A slow rate will also prevent damage to the equipment.)

What force was registered by the blow of the short lever? ________

What force was registered by the blow of the long lever? ________

If you had a series of clubs of graduated lengths, what would you expect to derive from their use in an experiment such as this?

What sports make use of a long lever?

In what sports is a shortened lever used on some occasions? What is the reason for shortening in each case?

SPORT	EXAMPLE	REASON

Lesson 16

Inertia

A resting body remains at rest if no external force operates upon it. (Resting inertia)

A body moving with uniform motion retains this state of uniform motion as long as there is no external force operating upon it. (Inertia of movement)

The resistance which a body offers to motion or change of motion varies directly with the mass of the object.

References Scott, M Gladys, *Analysis of Human Motion*, F S. Crofts & Co., New York, 1942, Chap VII

Luhr Overton, *Physics Tells Why* Jaques Cattell Press, Lancaster Pennsylvania, 1946 Chap 2

Equipment A pair of balls, one heavy and one light, such as a bowling or medicine ball and a volleyball or soccer ball. In a smaller size a hockey and a tennis ball will serve.

Project A To STUDY RESTING INERTIA IN RELATION TO MASS.

Place the two balls side by side on a level table Why do they remain there?

Blow on the two balls. Why does the light one move and the other not?

Replace balls side by side Close your eyes Push each ball gently with the hand. Is the difference in resistance to motion sufficient to be detected by the feeling of force necessary to move them?

Project B To study inertia of movement

Roll one of the balls along the floor Why does it stop?

Place the heavy ball a few feet away on the floor Roll the light ball so that it strikes the heavy one. What is the result? What type of inertia is demonstrated by this situation?

Reverse the balls, rolling the heavy ball into the light one. What is the result?

What sport situations illustrate inertia? State which phase.

Situation	Phase

List other situations encountered in daily experience which illustrate one phase or the other

Situation	Phase

If a person is trying to chin from a free hanging position (arms fully extended) and is unable to start moving, he frequently can do a full pull up if he can start with his toes lightly touching some support. Why?

A base in a tumbling stunt may be unable to lift the top from a standing position but will be able to do so if the top initiates movement at the proper time Why?

Lesson 17

Centrifugal Force

Any rotating object exhibits a centrifugal force which is a reaction to the force which holds it to its axis. If the whole or a part becomes detached it continues on a tangent to the arc through which it was rotating

Centrifugal force is greater in fast movements than in slow ones

Centrifugal force is greater on long levers than on short ones if moving at the same angular speed.

References: Scott, M Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap VIII

Luhr Overton, *Physics Tells Why* Jaques Cattell Press, Lancaster, Pennsylvania, 1946, Chap 3

Equipment Golf ball, handkerchief, string

Project To DEMONSTRATE THE EFFECTS OF CENTRIFUGAL FORCE.

Tie the ball securely inside the handkerchief leaving about 12 to 15 inches of string

Hold the string out at arm s length, whirl the ball slowly around, and note the amount of tension on the string as you hold it Release the string and note how far the ball travels before hitting the floor

Repeat, but whirl the ball rapidly enough so that the string is in approximately a horizontal plane. Note amount of tension on the string Then release and note distance covered before falling

Repeat above procedure but with only 6 inches of string

	Long	Short
Slow	________	________
Fast	________	________

Why does the ball not drop directly to the floor?

Variations in the four figures above indicate variations of what?

What estimate do you have of centrifugal force in each case?

Do double arm circling slowly and note feeling at shoulders Increase rate and note added tension at shoulders. Add a weight in each hand and repeat fast double arm circling note feeling around shoulder

During the arm circling was there any muscle force acting on the arms for any purpose other than moving the arms?

What track events make use of centrifugal force?

Rank them in order of the significance of this factor to successful performance

List pieces of playground equipment which may be dangerous because of this factor

Lesson 18

Measurement of Strength of Muscle Groups

Muscle effort of agonistic groups is measurable (1) as force pulling on some kind of dynamometer, or (2) as resistance to some force applied through the dynamometer

References Scott, M. Gladys, *Analysis of Human Motion*, F S. Crofts & Co., New York, 1942, Chap VI

Haxton, H. A., Absolute Muscle Force in the Ankle Flexors of Man, *Journal of Physiology* v 103 December 1944 p 267

McCloy C H., *Tests and Measurements in Physical Education* F S Crofts & Co., New York, 1942, pp 19-37

Equipment A manuometer with push pull attachment and a wide fabric or leather belt with buckle *A metal supporting device, which fits one side of the* push pull attachment, should be anchored to a board which may in turn be immobilized for different measures. (See Project C if this equipment is unavailable)

Project A TO MEASURE STRENGTH OF ARM AND SHOULDER GIRDLE MUSCLES.

1. Grasp each side of the attachment and hold in front of chest with arms in a horizontal position, elbows pointing to the side *Pull* as hard as possible without bracing dynamometer against chest. Record your score as Subject 1.
2. In the same position *push* in on the dynamometer as hard as possible but without bracing it against the chest Record your score as Subject 1
3. The dynamometer may be clamped in the supporting device and suspended overhead. (The entire board may be fastened to an adjustable horizontal bar or boom.) It should be at such a height for each subject that he can stand erect and with arm raised to grasp equipment making a right angle at the elbow—the upper arm forward in a horizontal plane and the lower arm vertical. Pull downward as hard as possible without changing from an erect standing position. (When men act as subjects, the feet may need to be held down to prevent chinning) Record your score on the chart

4 Secure similar scores from 9 other classmates.

5 Make any other measures you wish Describe them briefly and insert scores on the chart

Subject	Pull		Push		Downward Pull		*Others*			
	Score	Rank	Score	Rank	Score	Rank				
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
Muscles used										

For each measure taken list on the chart the principal muscles used. How would the muscles involved vary in the downward pull if the arm were sideward instead of forward?

Give a rank-order assignment to the pull scores, and to each successive set of scores you may have. Compare rank orders. Would you expect all of them to remain the same for each subject?

How would you explain the differences which you find?

Project B TO MEASURE STRENGTH OF ELBOW FLEXORS AND EXTENSORS.

Insert the belt through one handle of the push pull attachment and fasten it in a loop 12 inches or longer

Subject may be in any position in which the upper arm is supported on a flat horizontal surface The elbow should be flexed to 90° and lower arm should be in a vertical position. Put the strap around the wrist at the level of the styloid process of the radius, and extend outward in same direction the elbow is pointing Subject attempts to hold the forearm in the vertical position while examiner attempts to extend forearm by pulling on distant arm of attachment Pull steadily until subject loses position of forearm.

Record value registered on dial in column 1 below

The strength of which muscle group is measured by the above technique?

Repeat process but with belt coinciding with the direction of the upper arm and parallel to it. The examiner pulls until the subject's elbow flexes in spite of his efforts to hold the forearm vertical.

Record value registered on dial in column 2 below

Repeat with the forearm starting in less than 90° and again more than 90° Compare the results

The strength of which muscle group is measured by the above technique?

What other muscle groups might be measured in a similar way?

For each additional muscle group which you measure, diagram the position of the segment and the equipment.

Record the values of all measures taken Do the largest values belong to those muscle groups you would expect to be strongest and vice versa?

Subject	1	2	Others					
1								
2								
3								
4								
5								

Project C USE AN ORDINARY SPRING SCALE (OF THE TYPE OBTAINABLE IN ANY HARDWARE STORE) Attach a handle (or the belt) to the upper end use the hook on the bottom to fasten to a fixed support or as the handle for the examiner This scale may be used in either of the above projects

Why do strength tests not attempt to measure strength of a single muscle?

Is this force the same as the maximum potential force for the muscle group, assuming it were possible to obtain the physiological cross section of the muscles?

Why cannot this strength be accurately predicted by means of measuring the girth of the body segment in which the muscles are located?

Unusual Muscle Action

The origin of a muscle is defined as the proximal end and is usually considered as the fixed end when the muscle contracts

The insertion of the muscle is defined as the distal end and is usually considered as the movable end.

When a muscle contracts it exerts tension on both of its attachments.

Since there is tension at both attachments, it is possible that either or both ends may move Which of the two ends moves, is dependent upon the amount of resistance offered to the movement at the two ends

Variations in the plane in which movement takes place may also affect the way in which the muscle acts

When controlling the pull of gravity or the speed of a movement, the muscle sometimes actually lengthens while contracting

References
Scott M Gladys, *Analysis of Human Motion* F S. Crofts & Co., New York, 1942
Spalteholz, Werner *Hand Atlas of Human Anatomy* J B Lippincott Co., Philadelphia, Vol. II 1933
McCloy C H., Some Notes on Differential Actions of Partite Muscles, *Research Quarterly* v 17 December 1946 p 254

Project TO STUDY MOVEMENTS AND THE MUSCLE ACTION INVOLVED.

1. Which end of the latissimus dorsi moves
   (a) in the down swing of a tennis serve? ________
   (b) when hanging from a horizontal bar, trunk swinging forward? ________
2. Which end of the right gluteus medius moves
   (a) standing right leg abducted? ________
   (b) walking, supported on right leg left leg swinging forward? ________
3. Which end of the tibialis posterior moves
   (a) supine lying plantar flexion of foot? ________
   (b) squat sitting rising to standing position? ________

4. Which part of the pectoralis major acts

(a) arm hanging at sides, raised to position across face? ________

(b) returned to starting position against resistance? ________

(c) returned to starting position slowly? ________

5. Is the quadriceps extensor used

(a) in lifting weight up in mounting stairs? ________

(b) in lowering weight in descending stairs? ________

6. Add examples of situations in which the muscle performs differently from that action generally attributed to it?

Muscle	*Situation*
________	________________________________
	________________________________
________	________________________________
	________________________________
________	________________________________
	________________________________
________	________________________________
	________________________________
________	________________________________
	________________________________
________	________________________________
	________________________________
________	________________________________
	________________________________

Lesson 20

Biarticular Muscles

Biarticular muscles make possible indirect and passive movements in joints adjacent to those in which a uni-articular muscle is acting

References Scott, M. Gladys, *Analysis of Human Motion* F S. Crofts & Co., New York, 1942 Chap VIII

Brunnstrom, Signe, Some Observations on Muscle Function, *Physiotherapy Review* v 22, March, 1942, pp 67 75

Haines, R. W., Muscles of Full and Short Action, *Journal of Anatomy,* v 69 October 1934, pp 20-24

Steindler A., *Mechanics of Normal and Pathological Locomotion in Man* Charles C Thomas, Springfield, Illinois, 1935 pp. 102-106

Equipment Small strips of wood such as 1 by ½ or ½" by ½ , lightweight hinges and picture hooks.

Project To CONSTRUCT A MODEL OF THE LOWER EXTREMITY

Construct model according to dimensions suggested in the diagram. Hinge it to operate in same way as articulations of the lower extremity Arrows indicate direction in which movement should take place when hinged. Use picture hooks to fasten strings representing muscles. Adjust strings to represent rectus femoris, ham strings and gastrocnemius The foot may be kept from dropping by an elastic band for the tibialis anterior

When the model is finished, operate by hand as though uni-articular muscles were working Hold model with leg in vertical position. Pull front of pelvis and front of femur together Watch action of lower leg Which muscles are responsible for the action in the knee?

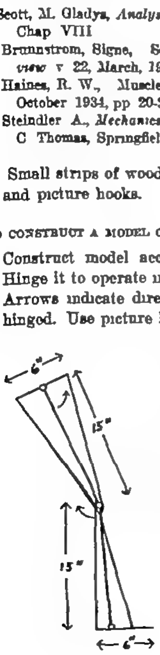


FIG. 21

Cite activities in which you have experienced this same effect.

Hold the model with the femur in a horizontal position and the lower leg hanging Note flexion of pelvis on the femur Now pull pelvis as though extending the pelvis on the femur Watch lower leg extend. (It will be held horizontally if strings were adjusted tight and do not stretch.) What muscle is responsible for the action at the knee?

What generalizations can you draw about the effect of the biarticular muscles on the lower extremity?

Lesson 21

Relaxation Related to Muscular Economy

Usually when a given group of muscles is stimulated to action their antagonists are allowed to relax.

Relaxation serves to conserve energy, to control momentum, to improve co-ordination, to promote endurance, and to avoid injury

References: Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chaps. VIII and XVIII
Schneider Edward C., *Physiology of Muscular Activity* W B Saunders Co., Philadelphia, 1939 Chaps. III XV

Equipment Appropriate for the acts performed.

Project To COMPARE EXPENDITURE OF ENERGY (AS JUDGED BY HEART RATE) IN PERFORMANCE OF AN ACT IN A RELAXED MANNER AND WITH LOCALIZED TENSION

Divide the class into couples. Each person must select a skill at which he can achieve a reasonably satisfactory level of relaxation in performing the act. Suggested acts are:

arm circling
bouncing a ball
jumping in place
wall board tennis practise
throwing balls for specified distance
(supply of balls coming from partner)
chair climbing exercise
volleyball serve
tennis serve
badminton serve

Add any others the class wishes, provided the rate can be kept relatively constant, and the action can be limited largely to the act defined and subject *to both styles of performance*

Subject sits quietly for 3 to 8 minutes, whatever time is necessary to achieve a resting heart rate. Take pulse for 30-second intervals until two consecutive readings approximately agree

Subject *performs* the specified act in as relaxed a manner as possible. Assistant helps to set rhythm and see that it is maintained, and times the duration of the act. (Length of time may vary from 15 seconds to 2 minutes depending upon the strenuousness of the activity and how soon some heart response may be expected.)

Subject sits immediately after cessation of activity and partner counts pulse for four consecutive 30-second intervals. At the same time *the partner observes breathing rate, general discomfort*, or other signs of fatigue.

Subject continues to sit until resting pulse rate returns to the rate at the beginning of the experiment.

Subject repeats the act at the same rate, and for the same length of time as before but "works harder," creating as much localized muscle tension in the performing areas as possible.

Again make a record of the 2 minutes of heart action and the accompanying evidence of fatigue.

Heart Rate

Resting rate	____	____		
Following relaxed action	____	____	____	____
Following tense action	____	____	____	____

BREATHING AND SIGNS OF FATIGUE

Following relaxed action	Following tense action

On what basis can you assume that increase in heart rate represents an increase in energy expenditure?

What would be a more exact means of determining the expenditure during the two performances?

Classify the activities performed by the whole class as light, moderate, or strenuous. Within each classification note the range in differences of pulse counts for the various individuals.

Light	*Moderate*	*Strenuous*

Is there a uniform increase for the tense performance?

Is there a tendency for the difference to be greater as the skill becomes more difficult and more complex?

Why is heart rate not a completely satisfactory measure of energy demands for the activity?

If you were relatively unskilled at the act and continued the tense performance over a period of time comparable to a practice period, what other evidence would you have after finishing of the effort involved?

What relationship has the development of skill to tension exhibited by the performer?

Does relaxation automatically follow from practice of the skill, and familiarity with the equipment and the nature of the performance? Explain

Can relaxation be taught? If so, give specific suggestions for the skill you were performing in this lesson.

Light			*Moderate*			*Strenuous*	

Is there a uniform increase for the tense performance?

Is there a tendency for the difference to be greater as the skill becomes more difficult and more complex?

Why is heart rate not a completely satisfactory measure of energy demands for the activity?

If you were relatively unskilled at the act and continued the tense performance over a period of time comparable to a practice period, what other evidence would you have after finishing of the effort involved?

What relationship has the development of skill to tension exhibited by the performer?

Does relaxation automatically follow from practice of the skill, and familiarity with the equipment and the nature of the performance? Explain.

Can relaxation be taught? If so, give specific suggestions for the skill you were performing in this lesson.

Light			*Moderate*			*Strenuous*	

Is there a uniform increase for the tense performance?

Is there a tendency for the difference to be greater as the skill becomes more difficult and more complex?

Why is heart rate not a completely satisfactory measure of energy demands for the activity?

If you were relatively unskilled at the act and continued the tense performance over a period of time comparable to a practice period, what other evidence would you have after finishing of the effort involved?

What relationship has the development of skill to tension exhibited by the performer?

Does relaxation automatically follow from practice of the skill, and familiarity with the equipment and the nature of the performance? Explain.

Can relaxation be taught? If so, give specific suggestions for the skill you were performing in this lesson.

Lesson 22

Rebound of Balls

When a moving ball meets a resistance greater than its momentum, it will rebound from that resistance.

The angle at which a ball approaches this resistance helps to determine the angle at which it will rebound.

References Scott, M. Gladys, *Analysis of Human Motion,* F S Crofts & Co., New York, 1942, Chap IX

Luhr Overton, *Physics Tells Why* Jaques Cattell Press, Lancaster Pennsylvania, 1946, Chap 4

Equipment A circular target on the wall 10" in diameter (The center of the target is 42" from the floor) A tennis ball in good condition, and chalk.

Project To STUDY ANGLE OF REBOUND OF A BOUNCING BALL.

Place a chalk mark 4 feet from the wall directly in front of the target. Performer stands back 8 feet from the wall, facing the target directly Feet may be spread but position should be such that in throwing the ball is released at a point 8 feet from the wall. Throw with a side arm action. Practice throwing at chalk mark on the floor with sufficient force to carry the ball to the wall. Partner uses a yard stick to estimate height of the ball when released. Try to make it approximately 42 inches.

For several successive throws estimate releasing height and hitting height on wall if contact point on floor is accurate Determine the angle of incidence and the angle of rebound for each such throw by use of a diagram drawn to scale as below

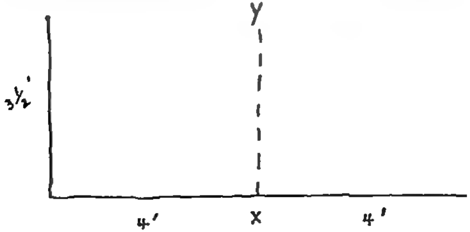


FIG. 22

Locating release point and striking point on wall, construct line of flight to and from point X. (Line XY represents the perpendicular.) The angle in each case can be read on a protractor.

How will speed of the ball affect the expected similarity of the two angles?

What other factors will affect the angle of rebound?

List the sports in which an understanding of the principles of rebound is important to the player.

Set up similar projects in other situations. For example: rebound of a basketball thrown against the backboard, rebound of a tennis drive (without spin), rebound of tennis serve delivered from various heights and traveling in different arcs, rebound of the ball in a throw against the wall, etc. Completion of these projects and comparison of results will help to answer the first two questions above.

Lesson 23

Spin of Balls

References Scott, M. Gladys, *Analysis of Human Motion*, F S Crofts & Co., New York, 1942, Chap IX
Luhr Overton, *Physics Tells Why* Jaques Cattell Press, Lancaster Pennsylvania, 1946, Chap III

Equipment Table tennis table, paddles, and ball Using ink, put circles around the ball.

Project To STUDY THE SPIN ON THE BALL, THE METHOD OF IMPARTING SPIN, THE EFFECT OF SPIN ON THE FLIGHT OF THE BALL, AND THE EFFECT OF THE SPIN ON THE REBOUND OF THE BALL.

Better results will be obtained if the demonstrator can play fairly slow balls but at the same time can control the amount and direction of spin.

Serve a series of balls without appreciable spin. Note the lines on the ball as it travels.

Diagram the path of the paddle before and at the moment of contact.

Diagram the path of the ball in flight and on the rebound.

Serve a series of balls with top spin. Note the lines on the ball as it travels.

Diagram the path of the paddle before and at the moment of contact.

Diagram the path of the ball in flight and on the rebound

Serve a series of balls with back spin Note the lines on the ball as it travels Diagram the path of the paddle before and at the moment of contact.

Diagram the path of the ball in flight and on the rebound.

Serve a series of balls with lateral spin. Note the lines on the ball as it travels Diagram the path of the paddle before and at the moment of contact.

Diagram the path of the ball in flight and on the rebound

Diagram the way in which top spin is put on a tennis drive.

Diagram the path of such a ball and compare with that of a ball hit in the same way except for top spin.

Diagram the effect of a bowling ball which is delivered with the thumb moving forward and the fingers back (supination) Explain.

The pitcher sends a ball to the plate high, but it drops a little just before reaching the plate The batter decides to swing thinking it will drop low enough for a strike. What is most likely to happen in this case, assuming that he does hit it?

Under what circumstances is the spin on a batted ball most pronounced?

Make a list of sports and cite situations in which spin is used to advantage in the game

Sport	*Situation*	*Value*

Make a list of sports and cite situations in which spin often works to the disadvantage of the player

Sport	*Situation*	*Value*

Draw a diagram of the angles of rebound for the two balls

In what other sports does a variation in amount of compression affect the playing?

Lesson 25

Angle for Projectiles

Any object projected into space is affected by the downward pull of gravity and air resistance, as well as the force which projects it.

The greater the angle with the horizontal the longer will the object stay in the air (if projecting force remains constant)

The less the angle with the horizontal, the greater the component of forward force However, the speed must be very great on an object traveling at or near a horizontal plane or gravity will pull it to the ground long before its forward momentum can be spent.

References: Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap IX

Luhr Overton, *Physics Tells Why,* Jaques Cattell Press, Lancaster Pennsylvania, 1946 Chap II

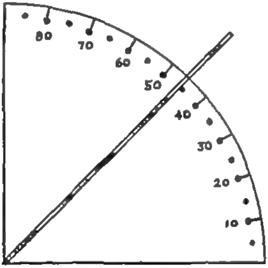


FIG 23

Equipment A ball, a large improvised protractor with a movable arm. (See diagram.) Use two light boards set at right angles for the framework. Fasten on a heavy cardboard marked through a 90° range. On the face of the device attach a long arm by a pivot arrangement. Perforations around the protractor makes it possible to insert a peg at any angle to hold the pointer in place. (The protractor may be placed on a support or hung beside the performer in order to facilitate throws at desired angles)

Project To COMPARE THROWS MADE AT DIFFERENT ANGLES WITH THE HORIZONTAL.

Throw a ball slowly near a horizontal plane. How far does it carry?

Throw it at about the same speed but near a 45° angle How far does it carry?

Throw it again at about the same speed but near a 75° angle. How far does it carry?

Repeat three throws at the respective angles but throw very hard.

	slow	*fast*
0°	___	___
45°	___	___
75°	___	___
___	___	___
___	___	___
___	___	___

Try other angles between those listed above. Record distances.

What is the optimum angle for a distance throw?

What sports require distance throws and hence thrown (or struck) balls released near the optimum angle?

What sports permit very near horizontal delivery of balls?

Lesson 26

Primary Planes of the Body

The primary planes of the body represent the gravital lines or center of weight in their respective directions

The external landmarks touched by these planes are used to describe the location of the planes.

The exact position of the primary planes varies with the body build and with the position of the various segments

References Scott, M. Gladys, *Analysis of Human Motion,* F S Crofts & Co., New York, 1942, Chap VII

Equipment Sheet of onion skin or thin paper, small piece of lightweight cardboard (a 5x8 filing card serves very well)

Project A To CONSTRUCT A MODEL FOR THE THREE PRIMARY PLANES OF THE BODY

Make a pattern by superimposing the thin paper over the pattern and tracing carefully Retrace on cardboard. Cut out pieces and assemble. Label each plane in terms of those of the body

What external landmarks does each plane contact?

How are these planes situated with respect to the base of support when standing on both feet?

How are these planes situated with respect to the base of support when standing on one foot?

How are these planes situated with respect to the base of support carrying a heavy suitcase?

How are these planes situated with respect to the base of support when carrying a pack on the back?

How are these planes situated with respect to the base of support when reaching down to lift a small child?

How does the location of the planes relate to the problem of stability?

Describe general procedures to insure optimum or at least satisfactory balance in lifting activities

Describe general procedure to insure optimum balance in reaching

List positions of various levels of stability from most stable to least stable

Project B To construct a model showing planes of the body other than the primary ones.

Cut other pieces to represent parts marked extras. Insert pieces to represent each of the planes in a position other than primary positions For example, illustrate planes through which motion may take place in the shoulder or hip joints

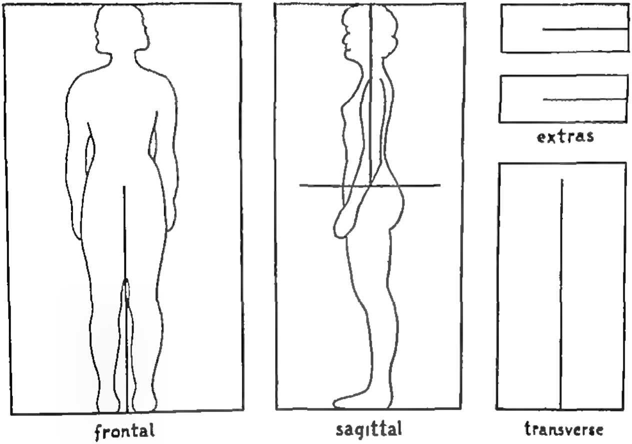


Fig. 24

Determination of Gravital Lines

The gravital line represents the weight bearing line.

The gravital line falls somewhere in the base of support.

The position of the gravital line shifts with changes in weight supported and changes in position of trunk.

References Scott M. Gladys, *Analysis of Human Motion* F. S Crofts & Co., New York, 1942, Chap VII XI

Hellebrandt, F A., and Corinne Fries, The Eccentricity of the Mean Vertical Projection of the Center of Gravity during Standing *Physiotherapy Review* v 22, July 1942, pp 186-192

Morton, Dudley J., *The Human Foot* Columbia University Press, New York 1935 Chap XII XIII

Palmer Carroll E., Studies of the Center of Gravity in the Human Body *Child Development*, v 15 1944 pp 99 180

Equipment One spring scale, one platform of height equal to that of the scale One board 200 cm. long with knife edge on each end, and heel board on top at center of board.

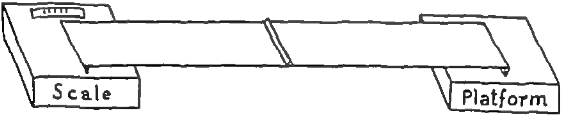


Fig. 25

Project A To locate the gravital line for antero-posterior balance.

I To determine weight line in an erect position. Weigh subject

Place board with one knife edge on scale and other on *platform*. Record weight of board.

Have subject stand, heels against heel board in good erect posture. Record weight

Trace outline of feet on a paper which had been placed under the feet and against the heel board Maintain the *same position* as during the weighing

Solve with the formula to find location of weight line

$$d = \frac{(\text{partial wt. of subject \& board}) - \text{partial wt. of board}}{\text{total weight of subject}} \times \begin{matrix}\text{length of board} \\ \text{(between knife edges)}\end{matrix}$$

where d = distance from rear knife edge to frontal plane

Compute point along the foot where this would be located by reference to foot tracing and heel board.

II. To determine weight line in foot when carrying a load of books in the arms in front of the body or a pack on the upper back.

Repeat as in I above but with subject loaded

III. To determine weight line in foot when hips are thrust forward and lower back hollowed.

Repeat as in I above except that subject stands in a relaxed slump with hips forward.

IV To determine weight line on foot when in high heels.

Repeat as in I above with subject standing erect in high heels.

Tracing should include outline of ball of foot and distance from heel board.

Find the location of the weight line as above.

Project B TO LOCATE GRAVITAL LINE FOR LATERAL BALANCE.

I. Same as AI but subject stands with side of one foot against heel plate, toes to edge of board.

Use a new tracing of the feet

Locate weight line in feet as above.

II Same as BI except that subject shifts weight so that it is borne entirely on one foot. (Place weight on foot next to heel board, make any necessary corrections in tracing of foot.)

Locate weight line on foot tracing as before.

If a photograph is taken at the same time as each of the weight measures the gravital line can be computed, superimposed on the picture later (A plumb line should appear somewhere on the picture Care must be taken to maintain proper scaleof distances on the photograph in making drawing)

What *general statements can be made about position of gravital line* over base of support

Where does the gravital line fall with respect to

hip

knee

ankle

What is the effect on each of those articulations?

How would you locate the approximate center of gravity by this technique?

Lesson 28

Body Sway

The body sways antero-posteriorly while standing erect.
No position is held motionless for an appreciable length of time

References Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap XI
Hellebrandt, F A., S Riddle and C Fries, 'Influence of Postural Sway on Stance Photography ' *Physiotherapy Review* v 22, March, 1942, pp 88-97
Hellebrandt, F A., L E. A. Kelso, and C Fries, Devices Useful to the Physiological Study of Posture, *Physiotherapy Review* v 22, January 1942, pp 10-16
Hellebrandt, F A., and Corinne Fries, 'Constancy of Oscillograph Stance Patterns, *Physiotherapy Review* v 22, January 1942, pp 17 23

Equipment (Same as Lesson 27)

Project To DETERMINE THE AMOUNT OF BODY SWAY IN A STANDING POSITION

While subject stands erect on board for 1 minute record highest and lowest readings on scale.

Solve for position of gravital line for each of these extremes. This range represents the amount of deviation of gravital line.

Why does this sway take place?

Is it greater when the subject tries to stand freely rather than trying to eliminate sway?

For a period of 8 minutes, try to keep the sway down below the point which can be measured by this technique. What is the effect on the subject?

Lesson 29

Locomotor Skills

Most forms of locomotion are basically the same, they differ in detail only

References Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap XII

Morton, Dudley J., *The Human Foot* University of Columbia Press, New York, 1935 Chaps. XV XVI XVII

Grace Margaret E., An Analysis of Certain Factors in the Gait of College Women, *Research Quarterly* v 14 October 1943 pp 294-309

Hartley Joel Gait and the Soldier *Military Surgeon* v 96 1945 pp 177 182

Morton, Dudley J., Foot Biomechanics Functional Disorders and Deformities, *Medical Physics* 1944 p 457-466

Steindler A., *The Mechanics of Normal and Pathological Locomotion in Man* Chas. C Thomas, Springfield, Illinois, 1935 Chaps. XXVII XXVIII

Idem Gait Physiologic and Pathologic Mechanics, *Medical Physics* 1944 pp 468-479

Truslow Walter *Body Poise* Williams & Wilkens Co., Baltimore, 1943, pp 242-248

Equipment It is preferable to have a film strip showing a normal walk with subject in swimming suit or other close fitting clothing Otherwise simply have members of the class walk in front of each other for observation.

Project To STUDY DETAILS OF THE WALK.

Study walking gait carefully First observe the swinging phase of the leg and then, using stick figures, draw a diagram of leg action

Then study supporting phase and draw diagram of leg action

Study arm action Draw a diagram.

Where does the force for the walk originate?

What would be the effect on the gait of the loss of the toes?

What would be the effect on the gait of a stiff ankle?

What causes excessive thumping of the heels in walking?

What are the most important muscle groups used in the swinging phase of leg action?

What are the most important muscle groups used in the supporting phase of leg action?

Observe running in the same way as walking Compare the run with the walk in the following respects

Force used

Timing

Leg action

Restraint

Body position

What are the chief differences between a slow and a fast run?

What are the chief individual anomalies to be seen in the gait of college students?

What are the chief individual anomalies to be seen in the gait of older adults?

Lesson 30

Hip Oscillations While Walking

The pelvis is subject to the thrusts of the supporting leg, the pull of the muscles, and the pull of gravity on the non supported side The result is that each side of the pelvis exhibits oscillations in antero-posterior, lateral, and vertical planes

References Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap XII

Steindler A., *Mechanics of Normal and Pathological Locomotion in Man*, Chas. C Thomas, Springfield, Illinois, 1935 Chap XXVIII

Equipment A yard stick or similar item, light rope or cord to tie stick on a level with lower sacrum, just above flare of gluteus maximus

Project To STUDY THE MOVEMENT OF EACH SIDE OF THE PELVIS DURING THE WALK.

Have subject walk about normally, except that elbows may need to be flexed to prevent arms from striking stick. The long stick exaggerates the swing of the pelvis and makes that movement more easily observed

When is the right side of the pelvis at its highest point?

When is the right side of the pelvis at its lowest point?

At what part of the right leg cycle is the right side of the pelvis farthest forward (in relation to the left side)?

Where is the left side at the same time?

At what part of the right leg cycle is the right side of the pelvis farthest back?

Where is the left side at the same time?

How does lateral oscillation compare in extent with the other two forms?

Under what circumstances can each of the three be increased in range?

Vertical

Antero-posterior

Lateral

Why do you use the adductors of the thigh during walking?

Why do you use the abductors of the thigh during walking?

Lesson 31

The Preparatory Movement and Follow-Through as Part of a Complete Act

References Scott, M. Gladys, *Analysis of Human Motion*, F. S. Crofts & Co., New York, 1942, Chap. XIII

Project TO USE STRIKING AS AN ILLUSTRATION OF THE EFFECT OF BACKSWING AND FOLLOW THROUGH.

Define preparatory movement in striking

Define follow through in striking

Use table tennis or paddle tennis, or other sport which can be performed in limited space. Observe extent of backswing and follow through in performance of several subjects. What value is received?

Then have each subject try to eliminate both parts. What is the result on the game?

In what sports is striking occasionally used with a reduced preparatory movement or follow through. State value received in each case.

Sport	*Value*

On the basis of these observations what generalization can you draw concerning the relationship of these two parts to striking State them as reasons which you would give a beginner for developing correct form on preparatory movement and follow through

Lesson 32

Kinesiological Analysis

References Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chaps. X, XIV, XV XVI

Project SELECT SOME ACTIVITY NOT ANALYZED IN THE TEXT AND WRITE A COMPLETE ANALYSIS.

Follow the outline given in Chapter X and the form in Chapters XIII and XIV of *Analysis of Human Motion* : Rewrite and correct carefully before filling in the outline below

Preparatory movement—Description

Act—Description

Follow through—Description

Preparatory movement—Muscular analysis

Act—Muscular analysis

Follow through—Muscular analysis

Preparatory movement—Mechanical analysis

Act—Mechanical analysis

Follow through—Mechanical analysis

Lesson 33

Variations in Throwing

References Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap XIII

Project To study variations in throwing

Check each of the following which is a form of throwing

__ basket shooting

__ softball pitching

__ sidearm pass

__ quoit toss

__ bowling

__ archery

__ kicking

__ volley ball serve

__ free throw shooting

__ hook pass in basket ball

__ shuffleboard

__ horseshoe pitching

__ fencing

Group the above according to similar form.

Select one form—for example, the underhand type of throw Make a complete analysis of *one* specific throw listed above which belongs to that type. Then note the points of difference for similar forms.

PREPARATORY MOVEMENT

	Basic Form throw 1	Differences throw 2	 throw 3
	Description		
	Muscular analysis		
	Mechanical analysis		

Basic Form Throw 1	Differences Throw 2	Throw 3
Description		
Muscular analysis		
Mechanical analysis		

FOLLOW-THROUGH

	Basic Form	Differences	
	THROW 1	THROW 2	THROW 3
Description			
Muscular analysis			
Mechanical analysis			

On the basis of the above analysis, list the principles which are common to all forms and which might be taught as general principles

Variations in Jumping

References Scott M. Gladys, *Analysis of Human Motion*, F S Crofts & Co., New York, 1942, Chap XIII
Equipment Mats or jumping pit desirable but not necessary
Project To COMPARE JUMPING FORM

Define the purpose of each of the following:

running broad jump

standing broad jump

vertical jump

In the chart below list the points of difference in each of the three jumps.

	Running broad	standing broad	vertical
Preparatory movement			
Act			
Follow through			

What principles are common to all forms of jumping and could therefore be taught as basic principles?

List examples of the use of jumping in sports or daily activities. Classify examples according to vertical, standing, or running broad.

Which principles learned previously concerning projectiles apply to the jumper?

Analysis of Skills in a Motion Picture Recording

Good film provides an opportunity for thorough observation and detailed measurement of all types of skills, simple and complex, fast or slow motion.

If films are made for this purpose, best results will be obtained if the following points are observed

1. Provide a contrast, if possible, between background and subject so that the outline of the body will be clear
2. Have subject wear a minimum of clothing or close fitting clothing
3. Insert markers which will show in film over articulations or other important landmarks
4. Take films in good light, prevent, as far as possible, shadows showing in the picture.
5. Take films from a long distance with a telephoto lens so as to eliminate the necessity for "panoraming" and to reduce the distortion of angular shots to a minimum. Keep the action of the subject in as short a space as possible.
6. Take pictures from all sides of the performer, including over head, if possible

References: Adams, Thurston, *Motion Pictures in Physical Education* Bureau of Publications, Columbia University New York, 1939 Chap IV

Dale, Edgar *Audio-Visual Methods in Teaching* Dryden Press, New York, 1946, pp. 429-442, 500-507

Gilbreth, Lillian, *The Home Maker and Her Job* D Appleton-Century Co., New York, 1938, Chap 6

Hoban, Charles F., and Samuel B Zisman, *Visualizing the Curriculum* Dryden Press, New York, 1946 pp 164-191

Equipment A strip of motion picture film of the skill being studied. A film reader of the type used in libraries (An additional vertical screen to enlarge the projected figure still more may be helpful.) Or a low powered hand projector may be used to throw the picture on a vertical screen or on the wall. A transparent ruler and protrac[illegible]

Project To ANALYZE A MOTOR [illegible] FROM A [illegible] RECORDING

Outline the p[illegible] to be [illegible]w the whole film with a regular projector [illegible] of the [illegible] to be studied.

Suggested outline for the preparatory part of a throw

- Starting position of hand, arm, trunk, and feet
- Path in which the ball is moved
- Wrist movement
- Amount of flexion in elbow
- Amount of abduction in shoulder
- Position of trunk
- Location of weight line
- Change in position of feet

A similar outline can be used for the rest of the throw, or for any other skill studied

Preparatory movement

Follow through

Determine the frequency of frames to be measured.
Project pictures in film reader and take measurement, record on outline above. If you have a picture of similar performance of two or more persons compare the various points of difference, especially where one form appears to be more effective
If you have only one performer, study the measures taken and from those write a description of the performance

Select the part of the performance which seems to be poorest.

Make a time-sequence outline of the various parts of the complete act.

List the points which are apparent in the film, but which are usually unnoticed in observing a performer

What are the chief advantages, from the standpoint of analysis, of a cinematic recording over observation of the actual performer?

Lesson 36

Floating and Swimming

Why does one person swim when put in water and another sink? Why is the theory, "If you throw the beginner in deep water where he has to swim, he can swim" a false one?

Buoyancy is the lifting force of a liquid on a body immersed in it. This lifting force is equal to the weight of the water displaced by the object.

A non buoyant object is one which displaces an amount of water weighing less than the weight of the object itself.

A buoyant object is one which displaces an amount of water weighing as much as, or more than the weight of the object itself.

Specific gravity is the ratio of the weight of an object to the weight of an equal volume of water.

Center of buoyancy is the point around which the upward buoying force of the water is equally distributed.

References Scott, M. Gladys, *Analysis of Human Motion* F. S. Crofts & Co., New York, 1942, Chap. XIV

Equipment Cork and piece of light wood, B-B shot or thumb tacks.

Project A TO DEMONSTRATE VARYING DEGREES OF BUOYANCY

Place a cork and a small piece of light wood on the water. Watch to see how high they float.

Why does most of the cork extend above the water level and only a small portion of the wood extend above?

Press a few small lead shots or tiny rocks into the pores of the cork, or heavy thumb tacks into the stick.

Why does it now float lower in the water?

Add shot until the cork is floating so that it just barely reaches the top of the water

What determines whether it will float or sink?

Project B DEMONSTRATION BY SWIMMERS OF VARYING DEGREES OF BUOYANCY

If you do not know the buoyancy of a subject, on what basis would you predict his capacity to float?

Have subjects do face floats, back floats, vertical floats.

Which is easiest for the non buoyant swimmer?

Which is most difficult for the non buoyant swimmer?

Why is the vertical float difficult for the buoyant swimmer?

Why is the vertical float difficult for the non buoyant swimmer?

It is possible to make adjustments of positions in the back float so that most swimmers can keep the face above water

List the various adjustments which help increase buoyancy, and in each case explain the reason why

Adjustments	*Reason it is helpful*

List the basic principles of successful floating

Surface diving is essentially the process of sinking the body that is, the opposite of floating It is possible, and often desirable, to submerge in a head first surface dive *without* swimming down. Indicate the principles above which must be considered and action which must be reversed if the person is to sink.

Describe a surface dive done as a process of *sinking* the body

Study the various arm and leg strokes For each, diagram the form which gives the greatest forward component and the least resistance to progress through the water

	Arms		*Legs*	
Strokes	Best component of force	Least Resistance	Best component of force	Least Resistance
Elementary back				
Side				
Breast				
Crawl				

There are two types of head first entries into the water The first is for covering distance as when making a racing start or a quick rescue. Describe the following points in such an entry

Depth of entry

Distance from the take-off

Direction force is applied

Position of body at take-off

Position of toes at take-off

Use of arms in take-off

The second type of entry is usually called a dive and is supposed to be an easy smooth entry graceful and coordinated in appearance, pleasant for the performer Describe the following points for a plain running front dive

Depth of entry

Distance from the take-off

Direction force is applied

Position of body at take-off

Position of toes at take-off

Use of arms in take-off

The contrast between the two forms is due principally to the same difference in purpose that exists between a broad jump and a vertical jump. Which of the differences in performance holds for both the jumps and entries into the water?

What principles should be taught to the swimmer so that he will learn to do two distinct types of entries, rather than something midway between the two which he would use for all occasions?

Details of Performance Explained by Muscle Action

References: Scott, M. Gladys, *Analysis of Human Motion*, F S Crofts & Co., New York, 1942, Chaps. III XIX
Brunnstrom, Signe, Comparative Strength of Muscles with Similar Function, *Physiotherapy Review* v 26 March, 1946 pp 59-65

Equipment Horizontal bar, or stall bars with top bar extended for chinning

Project To DEMONSTRATE MUSCLE ACTION IN SIMILAR PERFORMANCES.

Form 1. Subject grasps bar with hands shoulder width apart and palms toward face (forearm supinated) Pull up to chinning position. (If subject cannot pull up, start in a chinning position and lower very slowly Some of the same effect will be demonstrated though not as clearly) Note ease of grasp and position of elbows during pull.

Form 2. Subject repeats performance placing hands shoulder width apart with palms turned away from face (forearm pronated) Note effect on grasp and position of elbows during pull.

Form 3 Subject repeats again, placing hands about twice the distance apart as before, and palms turned away (pronated) Note grasp and position of elbows.

Which is the easiest?

Which is the most difficult? Why?

Why does spreading the hands in Form 3 make a distinct difference in ease of motion from Form 2?

What muscle is largely responsible for the difficulty experienced in Form 2?

Make a complete kinesiological analysis of the pull up in each of the three forms according to the following outline.

		1	2	3
Grip on bar	Description			
	Muscles			
	Mechanics			
Elbow flexion	Description			
	Muscles			
	Mechanics			

		1	2	3
Shoulder action	Description			
	Muscles			
	Mechanics			
Shoulder girdle movement accompanying arm action	Description			
	Muscles			
	Mechanics			

As a result of this study, which form of the pull up would you recommend if doing it as a test for making the greatest possible number of chinnings?

If you wished to develop other muscles, which other form would be most desirable?

If doing sit ups, will you do a larger percentage of the work with the abdominals if the trunk is straight or flexed? Why?

If doing sit ups, will you do a larger percentage of the work with the abdominals if the hip joints are straight when lying back, or if they are flexed so that the soles of the feet are on the floor? Why?

What factors determine how many and which synergists work in a given act?

Lesson 38

Selection of Exercises for a Specific Need

Any exercise used should serve a definite purpose

The effect of any exercise depends upon certain factors The most significant are

1. speed with which the exercise is performed
2. the amount of assistance or resistance offered
3. the duration of the exercise
4. the difficulty or amount of effort necessary

References Scott, M. Gladys, *Analysis of Human Motion* F S. Crofts & Co., New York, 1942, Chap XIX

Project To SELECT EXERCISES FOR A SPECIFIC NEED

Make a selection of an exercise for each of the following needs and analyze it according to the outline provided.

Condition kyphosis *Muscular or mechanical cause:* ________

____

Proposed exercise ________________________________

____

Muscles ________________________________

Speed ________________ *Repetition* ________________

Assistance ________________ *Resistance* ________________

In what way does the exercise counteract cause listed above?

Condition round shoulders *Muscular or mechanical cause* ____________

____

Proposed exercise ____________________

____

Muscles ____________________

Speed ____________ *Repetition* ____________

Assistance ____________ *Resistance* ____________

In what way does the exercise counteract the cause listed above?

Condition relaxed abdomen *Muscular or mechanical cause* ____________

____

Proposed exercise ____________________

____

Muscles ____________________

Speed ____________ *Repetition* ____________

Assistance ____________ *Resistance* ____________

In what way does the exercise counteract the cause listed above?

Condition lordosis *Muscular or mechanical cause* ____________

____

Proposed exercise ____________________

____

Muscles ____________________

Speed ____________ *Repetition* ____________

Assistance ____________ *Resistance* ____________

In what way does the exercise counteract cause listed above?

Condition longitudinal arch weak *Muscular or mechanical cause* ________

____

Proposed exercise ________

____

Muscles ________

Speed ________ *Repetition* ________

Assistance ________ *Resistance* ________

In what way does the exercise counteract cause listed above?

Condition fatigue posture (slump) *Muscular or mechanical cause* ________

____

Proposed exercise ________

____

Muscles ________

Speed ________ *Repetition* ________

Assistance ________ *Resistance* ________

In what way does the exercise counteract cause listed above?

Condition low endurance *Muscular or mechanical cause* ________

____

Proposed exercise ________

____

Muscles ________

Speed ________ *Repetition* ________

Assistance ________ *Resistance* ________

In what way does the exercise counteract cause listed above?

Lesson 39

Relationship of Eyes to Balance

References: Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap XX

Project To demonstrate the importance of the eyes in certain activities where balance is important

1 Stand on one foot with the other foot placed against the supporting knee, hands on hips, eyes open. A two- or three-minute stand is probably very simple

Now take same position and close eyes. Time the duration of the stand without moving or opening the eyes. ____________________

2 Walk a balance beam (or a straight line on floor) with eyes open. Repeat the performance with eyes closed. Compare results.

3 Do a series of rapid forward rolls, or spin around rapidly in an erect position until sensation of dizziness develops Try standing with eyes closed

Later repeat again, but while trying to recover normal equilibrium, focus on a point some distance away at eye level Compare results.

4 Feet together assume a squat sitting position (heels may be lifted from floor), hands on hips. This doubtless is not a problem of balance for the majority of the class

Then close the eyes and see how many lose the balance in less than 30 or 60 seconds Describe feeling of stability in the two instances.

5 Try single squat horizontal balance bear dance, or other balance stunt which you already know how to do Try it with the eyes closed.

What factors help to compensate for lack of vision?

Would your performance improve if you practised without using sense of vision?

Kinesthesia and Motor Performance

Kinesthetic sense gives an awareness of position of body parts and change of position of body segments.

We learn to react to kinesthetic sensations from other motor acts One sensation of movement may then be the stimulus for another movement.

Such a sequence of sensation movement sensation movement is essential to coordinated skills

References: Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chaps. IV XX

Bowen, W P., and R. T McKenzie, *Applied Anatomy and Kinesiology* Lea and Febiger Philadelphia, 1934, Chaps. III XIII

Eggleston M. Grace, *Muscular Exercise* Paul, Trench, Trubner & Co., London, 1936 pp. 195-205

Equipment A large protractor (can be constructed on a large piece of cardboard) It should provide for 180° range with markings in 5° intervals Readings can be approximated to the nearest degree.

Project A To PRODUCE MOVEMENTS ENTIRELY BY FEELING OF MOVEMENT AND POSITION

Subject must have eyes closed or be blindfolded throughout.

Subject stands with right side toward protractor which is hung on the wall so that center of radii coincide with center of shoulder joint.

Ask subject to raise right arm straight forward and hold it there Record degrees. ____________

Then ask subject to raise left arm to same position and hold. Record degrees. ____________

Lower arms. Ask subject to raise both arms at once forward horizontal Record position of each arm. R____________, L____________

Ask subject to keep left arm in horizontal plane while moving it sideward to frontal plane raise it upward into a vertical position, then lower it forward to a position matching the right arm. How successful was he?

Repeat similar movements to other positions which can be described to the subject. Take readings on the protractor. Would you describe his errors as large or small?

While subject stands, have him raise one foot and with the finger of the opposite hand touch the end of his toe. Why is he able to succeed in this?

Have subject bend head toward one shoulder as far as possible and walk down a straight line on the floor. Why are errors made?

Project B TO DEMONSTRATE THE VALUE OF THE KINESTHETIC SENSE IN LEARNING NEW SKILLS.

Select any skill which you do not know. (You may have to take some skill which you already know but which is unilateral and in which dominance makes considerable difference. Learn it as a new skill on the non-dominant side. It may be a throw, a volleyball serve, a badminton serve, batting, bowling, etc.)

Make a first attempt. Decide what you will do to try to improve.

Analyze the basis for your suggestions to yourself. How much of your analysis is based on such things as the way it feels, comparisons with the way it ought to feel to be like the other side or other similar skills you know, feeling of awkwardness, stiffness, and lack of balance?

Proceed with practice, if necessary on several successive days. Note the gradual development of a sensation of ease and smoothness and whether or not you learn to a highly successful and well coordinated level in the time you have, you will at least develop a feeling of assurance and ability to repeat fairly consistently whatever form you have acquired.

Lesson 41

Flexibility Development

An articulation or segment is said to be flexible if it permits easy and free movement It usually implies a relatively wide range of movement as it is commonly experienced in such an articulation.

Flexibility, or wide range of motion, is dependent upon several factors

1. degree of relaxation of antagonistic muscles
2. degree of elasticity and pliability of antagonistic muscles
3. length of ligamentous and capsular structures around the joint
4. amount and shortness of fascia over the muscles
5. strength of muscles to produce movement.

References: Scott, M. Gladys, *Analysis of Human Motion* F S Crofts & Co., New York, 1942, Chap XX

Project A To consider the problems and values in development of flexibility

If you were starting to develop flexibility in a certain articulation, which of the five factors listed above would you start investigating first? Why?

In which two factors would a person ordinarily be expected to show improvement most readily?

In which factor would you be most hesitant about effecting decided changes? Why?

Project B TO COMPARE RANGE OF JOINT ACTION WITH RELAXED AND TENSE MUSCLES.

Sit with leg stretched out straight and all extensors contracted Have assistant try to dorsal flex the foot How far will it move? Why not farther?

Let leg relax and bend the knee. Have assistant try to dorsal flex the foot. How far will it move? Why does it go further than before?

Why does it stop where it does?

Might it be possible to stretch the muscles limiting that action? Suggest an exercise which would do it.

Why would the stretching of those muscles be relatively difficult?

Might it be possible to stretch the capsule to permit more motion?

Would such stretching be advisable for most persons? Why?

What physical education activities frequently call for flexibility beyond the range of some members of the class? What articulations are most frequently limited in each case?

Activity	*Articulations Deficient*

What is the most common cause of inflexibility in articulations listed above? Suggest means of increasing flexibility

Articulation	*Cause*	*Recommendation*

What is the relationship between flexibility and economy of action?

What is the relationship between flexibility and injury?

PART III

The experiments in this section are not suited to a single day's laboratory period or for the daily study session, as most of the earlier ones are. Each will require careful planning and preparation of special equipment and collection of data over a period of time. If time permits assignment of additional problems, they may be assigned early in the course and worked up for special reports. Or, the more advanced students may find them helpful in setting up projects to broaden their experience in kinesiological techniques.

SUGGESTIONS FOR CONDUCTING ALL EXPERIMENTS

1. Use source materials suggested for your reading Be on the alert for new material in the literature.
2. Be sure the subjects cooperate. Members of the class will probably be more interested than outsiders Sometimes by two or three working on the same project and serving as subjects themselves, good results can be obtained.
3. Be very careful in planning and arranging all equipment. Use all the information available for planning a logical setup
4. If equipment has to be maintained over a period of time, recheck it carefully each time it is used to be sure it is working and set up properly
5. Be sure the subject always understands exactly what is expected.
6. Be extremely careful concerning the accuracy of all records
7. Different groups of students should work on different projects if equipment is scarce
8. Study evidence carefully, relate it to principles learned, and anticipate application to later professional problems.

Lesson 42

Developing Muscle Strength

Muscles increase in strength when used regularly against gradually increasing loads or resistance

Project

1. Select one or more subjects (preferably more than one) who are found to have approximately the same flexing strength in the little finger of each hand

2. Put the little finger of the left hand in a light splint and keep it there for 2 weeks. (A tongue depressor may be bandaged on or applied with adhesive. It can be replaced easily with a clean one from time to time. Learn how to apply splint properly so as not to stop circulation.) The splint should immobilize the metacarpal phalangeal articulation as well as the interphalangeal ones. (For greater convenience of subject, reverse hands if subject is left handed.)

3 Give the finger of the right hand daily exercise. Place the arm in a horizontal position. Attach a tape to the distal segment, run a cord through a pulley and suspend a weight on it. Start with a weight just under the maximum which the subject can move with his finger Have subject fully flex finger as many times successively as possible. Repeat next day Then on each succeeding day slightly increase the load by equal amounts each day

4 Continue experiment for the third week if necessary

Equipment

1 For measuring strength of fingers in flexion

Fasten a push pull attachment with dynamometer, or spring scale, so that the little finger can be hooked to the apparatus while arm is supported in a horizontal position. Apply on the distal segment and arrange so that the last two segments of fingers are approximately vertical when applying force

2. For exercising right finger

Use an arm chair or a table at which the subject can be seated comfortably with forearm flat on support palm and forearm facing up Attach a small pulley on edge of table so that cord from finger may pass through pulley and hang toward floor On the end of the cord attach a small bag with an opening through which weights can be added easily Use small shot or sand carefully weighed

Records to be secured

1 *Strength of each* finger on starting

2. Number of flexions possible each of the 14 days.

3 Amount of weight lifted each day

4 Strength of each finger on the 7th and 14th days (21st)

Suggested variations in setting up the study

1. Use several subjects all given the same kind of daily exercise

2. Use one or more subjects with gradually increasing load, and another subject or group using the same load throughout the period.

3 Same as (2) except the second group moves a submaximal load

4 Same as (2) except the second group moves a load a stated number of times—considerably less than maximal number of times.

Organization of data

When work with the subjects is completed, study the results carefully and organize in some form to show significant facts Write up conclusions to be drawn from the study

Lesson 43

Developing Muscle Tonus

Muscles improve in tonus when used regularly

Project

1. Secure one or more subjects who will agree to 12 to 15 minutes of daily exercise of a specified type for 3 weeks. Subjects should not have excess fat over the abdominal wall, nor have excessively tight and strong abdominal muscles Take a side view picture of the subject standing relaxed in the nude or in a close fitting swimming suit.

2. Plan a series of exercises for abdominals such as curling, feet lifting, back flattening, sit ups, standing trunk flexion, etc. Plan carefully so as not to get excessive soreness at the start, but by gradually increasing rate and number of repetitions, and resistance and difficulty of the exercise, the subject will become more proficient in the exercises. (Full cooperation of the subject is essential.)

Equipment

Photographic equipment such as used for posture pictures, or any camera.

Records to be obtained

1 Photograph before and after exercise period with study of contour of abdominal wall.

2. Inspection and subjective estimate of tonus of abdominals before and after exercise period.

3. Record of number of sit ups (or other chosen exercise) possible on first and last days of experiment.

Organization of data

Write a brief summary of results observed and measured.

Lesson 44

Development of Kinesthetic Pattern of Skills as a Basis for Understanding Motor Performance

Project

Select some activity which you have never tried, in which you can secure either an experienced performer or a film of the activity, and on which you will have an opportunity to practice

You will get best results if it is some activity which is rather complex and different from known skills It might be diving, some tumbling stunts, an apparatus event, trampoline exercise, or dance movements.

Observe the performance of the demonstrator or review the film. List the details of form which you see and cues which you pick up on how to do it.

Describe your feelings and reactions to the demonstration.

Practise regularly for [illegible] to 20 lessons depending upon how difficult it is to acquire this skill. It should be a regular class situation or one in which you get instruction and correction on form.

At the end of the series of lessons, again observe the same performer or film. List the details of form which you see in the demonstration.

Describe your feelings and reaction to the demonstration.

Records to be obtained

List of details observed before and after experience

Notes on kinesthetic feelings accompanying observations before and after experience.

Organization of data

Compare records made

Analyze results in terms of significance for

1 use of films in connection with teaching learning of sports
2. appreciation of dance or other skilled performance
3 analyzing activities for teaching purposes.

Lesson 45

Effect of Various Types of Stretching of Muscle

All muscles can be stretched some but the response of the muscle to stretching depends upon the extent of the elongation and the rate at which it is extended.

Project

Select one subject (or more) with a pair of shortened muscles, who is willing to cooperate in trying to stretch the muscles The anterior adductors of the shoulder joint are preferable because of the ease of measuring their strength and their effect on the shoulder girdle. (However, it may be possible to work on the hamstrings or the gastrocnemius-soleus)

Obtain a measure of the strength of the muscles, and observe position of the shoulder girdle on the thorax (or position of the articulation and tension of the muscles if working on other muscles)

Then devise a means of applying weight in uniform amounts and at definite rates. (For example, if working on the adductors of the shoulder, the subject may be placed on a plinth or other narrow support. One side may be stretched by allowing the arms to hang out about shoulder height in a relaxed position with the weight of the hand stretching relaxed muscles The other side will be stretched by forcibly pulling the arm down rhythmically)

Exercise should be repeated for at least 2 five- to ten minute periods per day for 2 or 3 weeks.

Measure strength of muscle and observe position of shoulder girdle on the thorax.

Records to be obtained

Measure of strength of muscle group before and after period of stretching

Subjective observation and measure of position of the scapula and point of the acromion

Organization of data:

Compare measures taken before and after stretching

Consider application of findings to

1. kind of exercises to use for muscle stretching
2. effects of different sports

Lesson 46

Learning a Motor Skill

Learning of motor skills is accomplished through careful, systematic practice. The optimum type of practice and distribution of practice periods is probably determined by the complexity and strenuousness of the activity These in turn are partially related to localized muscular endurance, general endurance, development of satisfying kinesthetic feelings.

Project

Select subjects of similar motor ability

Select some activity which is new to the subjects and which is simple enough so that it can be learned within a few hours time, and that can be standardized in teaching procedures

Plan system for learning which will permit comparison of results of stated number of practice hours spaced in different ways. For example, two-hour sessions on every third or fourth day, or one-hour sessions on alternate days, or half hour and quarter hour sessions daily Plan lessons so material is covered in same order and within the same time allotment.

Measure ability of each subject by predetermined tests of acceptable value.

Describe form and type of error made

Records to be obtained

Measure of ability at end of learning period.

Analysis of form at end of learning period

Organization of data

Compare the levels of skill reached by each group.

Lesson 47

Comparative Study of Gaits

Variations in the walk are sufficiently pronounced to be considered as identifying characteristics for the individual

Variations in the walk are, for the most part, exaggerations of some parts of the walk.

Project To STUDY ATYPICAL WALKS (AFTER COMPLETION OF LESSON 29)

Get preliminary practice in observing walks in order to aid in planning the rest of the study

Decide whether you will study gait only over a level surface, only on ascent or descent of a hill, ascent or descent of stairs, or whether you will concentrate on a few individuals in as many situations as possible

Plan an observation card to be used for each subject. It might include items as follows

	Normal	Deviations
Leg contact		
Leg support		
Push-off		
Leg swing		
Hip oscillations		
Arm swing		
Trunk position		
Length of stride		
Rate of walk		

Why attracted to the walk

Lesson 48

Comparison of Form Exhibited in Motor Skills during Learning Stages

Project

May be combined with Lesson 46 by observing subjects during learning for that project

Plan a detailed observation sheet on details of form for the skill studied and practise using it.

Observe learners regularly (daily or weekly) during learning period.

Records to be obtained

Observation check lists on each subject.

Organization of data

Make a composite description of the learner at definite stages of achievement.
Select individuals who typify the learning rate.
Analyze form at each stage for

1. causes
2. success
3. probable coaching pointers needed.

Measurement of Strength of Muscle Groups

Project

Select a series of measures of strength of different muscle groups according t equipment available and interest in machine or non machine type

Practice technique of administering tests

Select subjects from a homogeneous group, or from various well-defined group for purposes of comparisons

Administer tests.

Records to be obtained

Test scores for each subject.

Organization of data

Compute average on each test for each group of subjects

Compute standard deviation and critical ratio between groups if you are familia with those techniques and have enough cases (30 or more in each group)

Compare individual performance with norms if such are available.

Interpret results in terms of following points

1. relationship of strength to muscular endurance
2. comparative ease of administering different tests
3. probable importance of having strength in muscular groups tested
4. explanation of wide individual variations if such were found.

Analysis of Newspaper, Radio, or Magazine Exercise Series

Project

Select an exercise series designed for reducing, beautifying the figure, developing strength, or whatever purpose may be suggested by the source Obtain a newspaper or radio series of several days or weeks duration if possible Otherwise ask students for the "daily dozen" which they use, or get the list of conditioning exercises being used in physical education classes.

Analyze each exercise carefully in terms of muscles used, probable effect for rate and duration suggested by source. Try exercises on a small group of subjects to verify judgment. It may require the observation of subjects performing the entire exercise series

Organization of data

Present logical interpretation of each exercise and of the entire series

Present recommendation for value to be expected and changes to be made if exercises are inadequate.